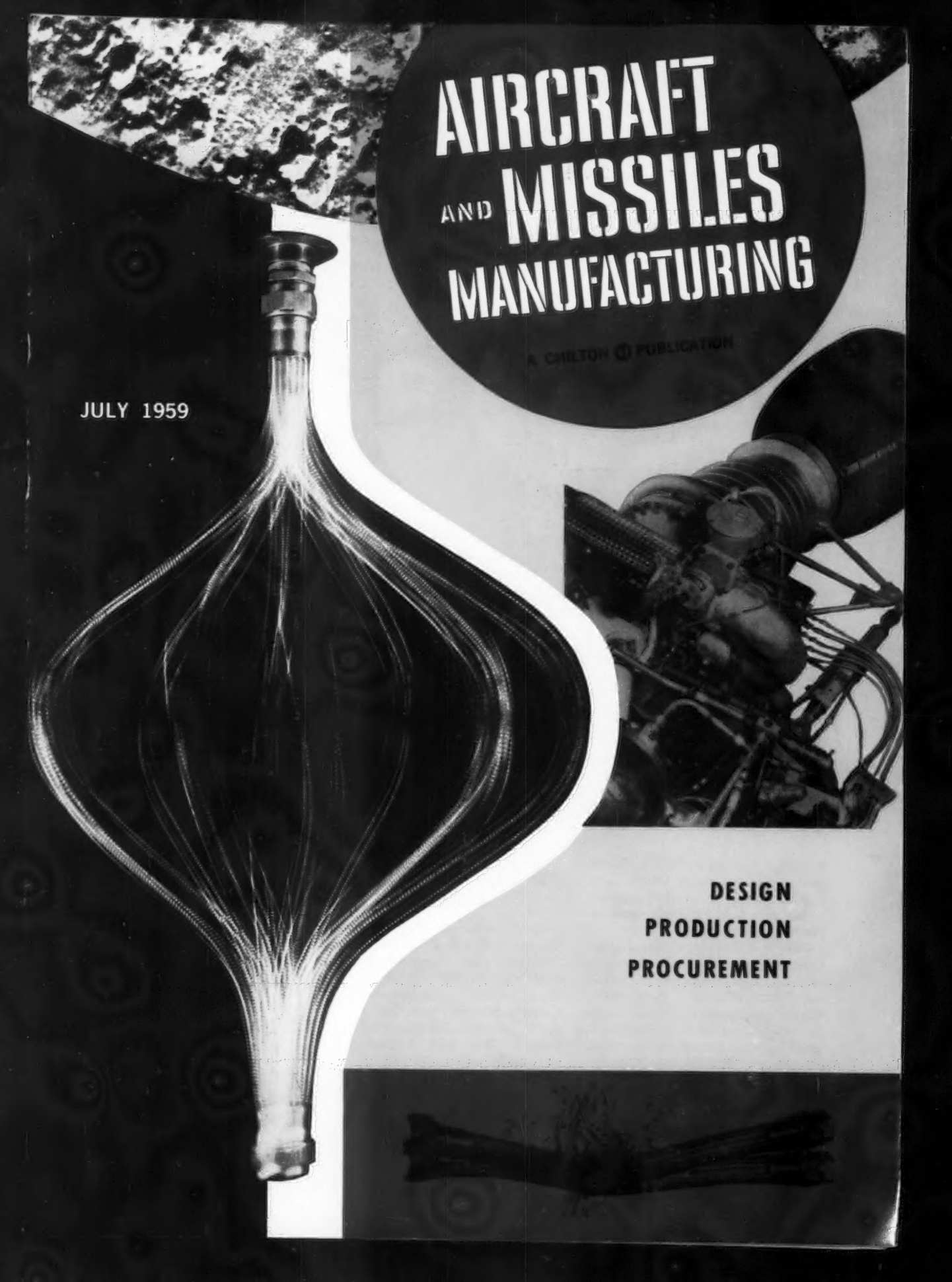
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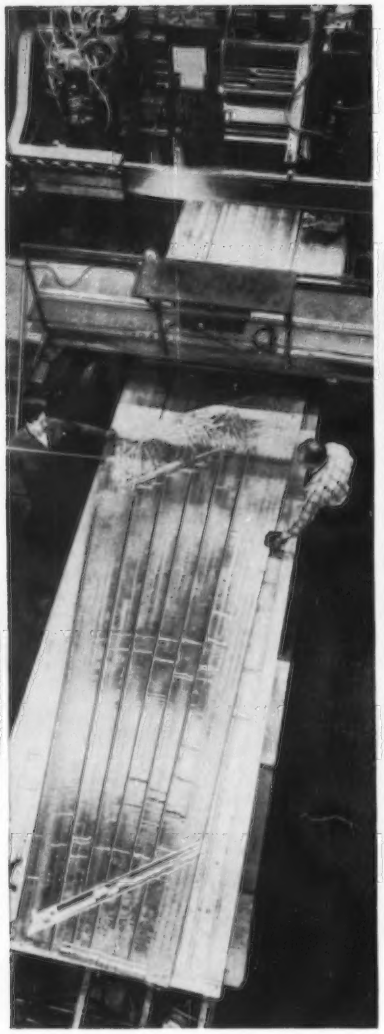

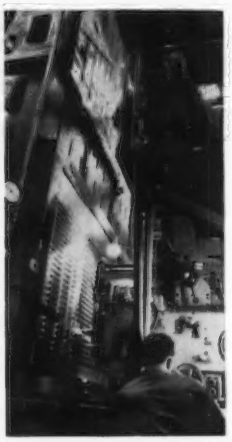

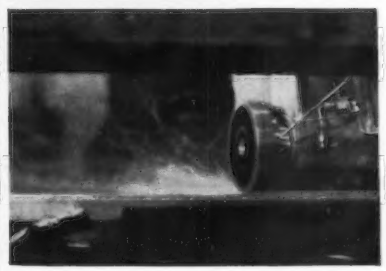

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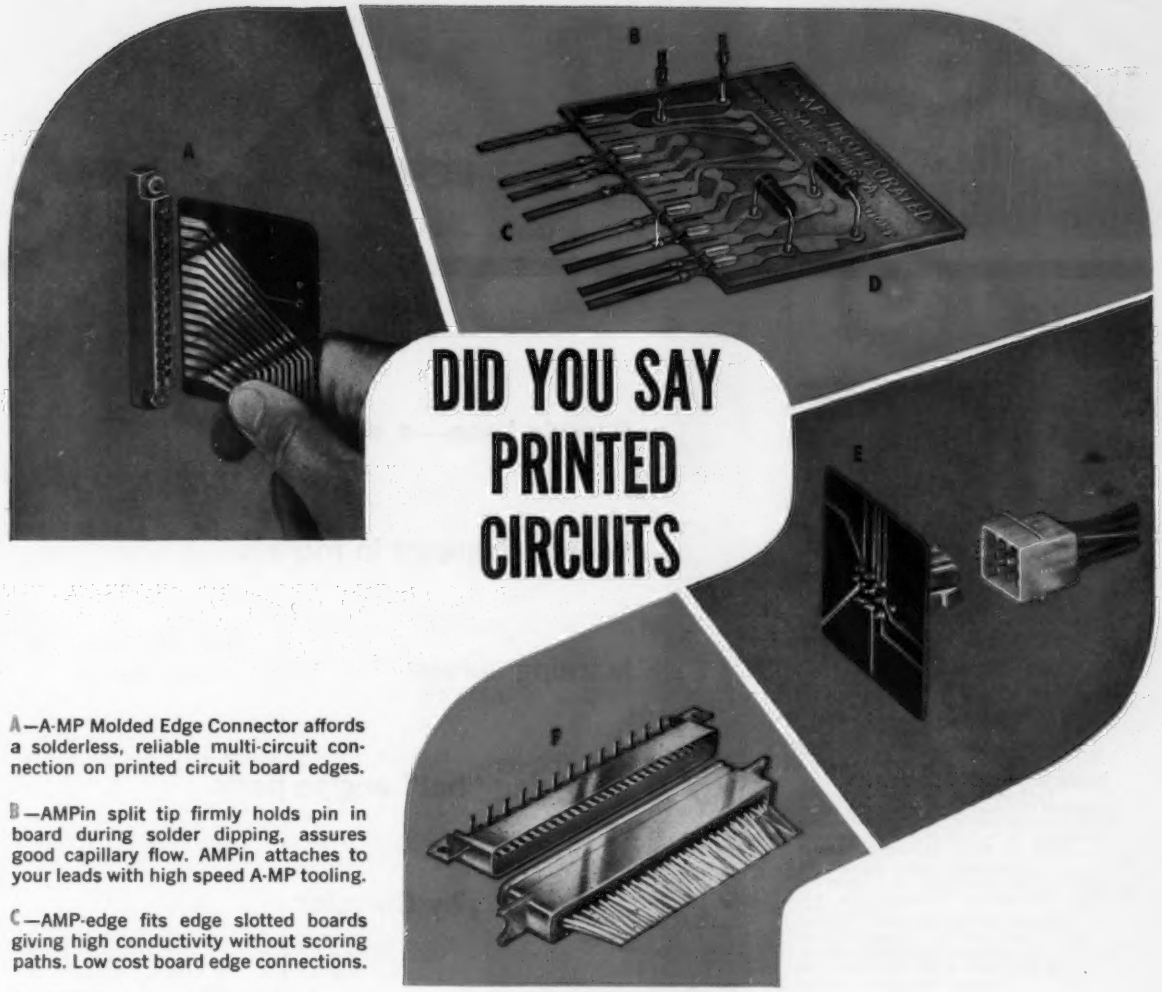

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AIRCRAFT AND MISSILES MANUFACTURING

JULY 1959
volume 2, number 7
DESIGN
PRODUCTION
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features

PAGE	
6	flexible hose—a status report
12	thrust alignment in rockets
16	learning curves
22	designing "hot" engine parts
26	Jupiter . . . by Chrysler
32	circuit-breaker simulator
34	needed . . . "more gear" per dollar
38	SS-10 and SS-11 join Army arsenal
42	Britain's Vickers Vigilant
44	ground-testing the ramjet
48	what makes the TU-104 so hot?

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THE COVER STORY

The theme of this month's cover is the flexible hose as used in the design of today's aircraft and missiles. As a vital link in the reliability chain, flexible hose is being called upon to fulfill increasingly difficult fluid-transfer assignments. Inset at bottom of page illustrates what takes place during a typical destructive test combining pressure and flexure cycling.

departments

PAGE		PAGE	
4	editorial orbit	63	men on the move
50	materials and components	65	worth asking for
		69	reader's orbit
58	new for production	80	your date book

industry notes

PAGE		PAGE	
67	bringing a space capsule down	71	sealing unlimited
		72	Brequet unveils STOL
69	promising process for molybdenum	73	facilities
69	Army lists priorities	73	outlook—materials and processes
70	contract awards	74	terra-scope

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neatness—yardstick to progress

This is a personal report about *you!*

During the course of my travels, I've heard many executives in the industry state that there are numerous engineers who do not make an impressive, executive-type appearance. Often the comment runs something like this, "He's one of the finest engineers we have and has an excellent personality, but he certainly doesn't make a good appearance to our customers."

Tom Campbell, Editor-in-Chief of The Iron Age, wrote an editorial on this subject some time ago. Tom had some very good points on "getting ahead." Let's quote him on some of these.

"Keep your shoes shined and your heels straightened if you are on your way up. It doesn't cost much, but it is valuable."

"When in the front office, don't show that inch of flesh when you cross your legs. Wear garters or socks that will stay up."

"If your suit looks as if you slept in it that's the way it will look to those who are *looking you over.*"

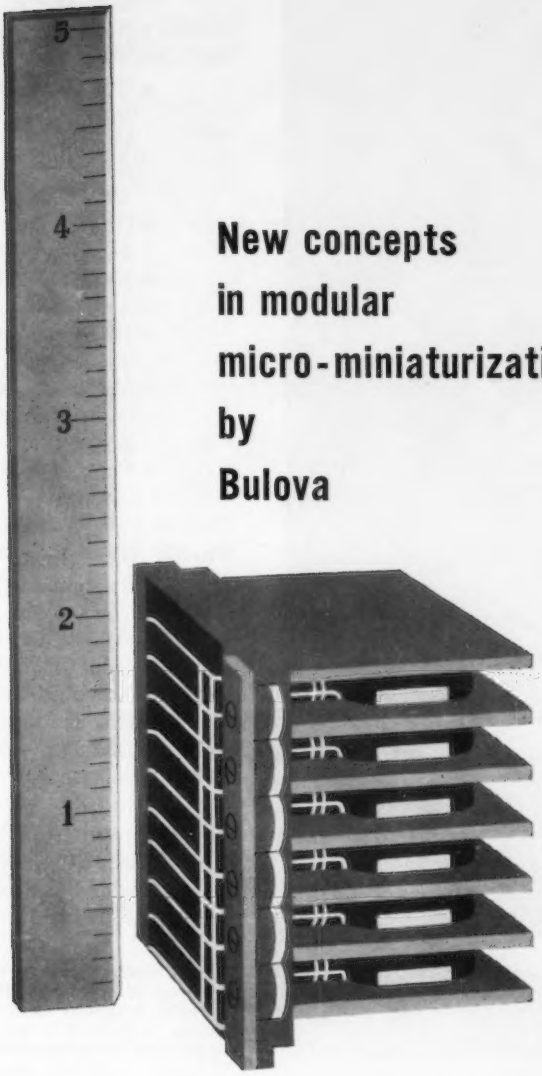
"Better leave wild neckties to those who are already on top. They can wear what they like, you can't if you want to get where they are."

"Don't use a toothpick while out to lunch with the bosses. Don't pick your teeth with matches, match folders, or forks—it centers the wrong kind of attention upon you."

Remember when you're out on company business, *you* are the company. Your appearance establishes a part of the company image. Neatness often means efficiency in the minds of those dealing with you. Would you go to a doctor who appeared unkempt with mussed garments and dirt under his fingernails? I don't think so.

A salesman, who is intelligent, well organized, and neat in appearance, impresses people with the company that sent him. Your management feels the same way about *you.* It wants to have a good corporate image. Success to your firm might well mean success to you.

Editor



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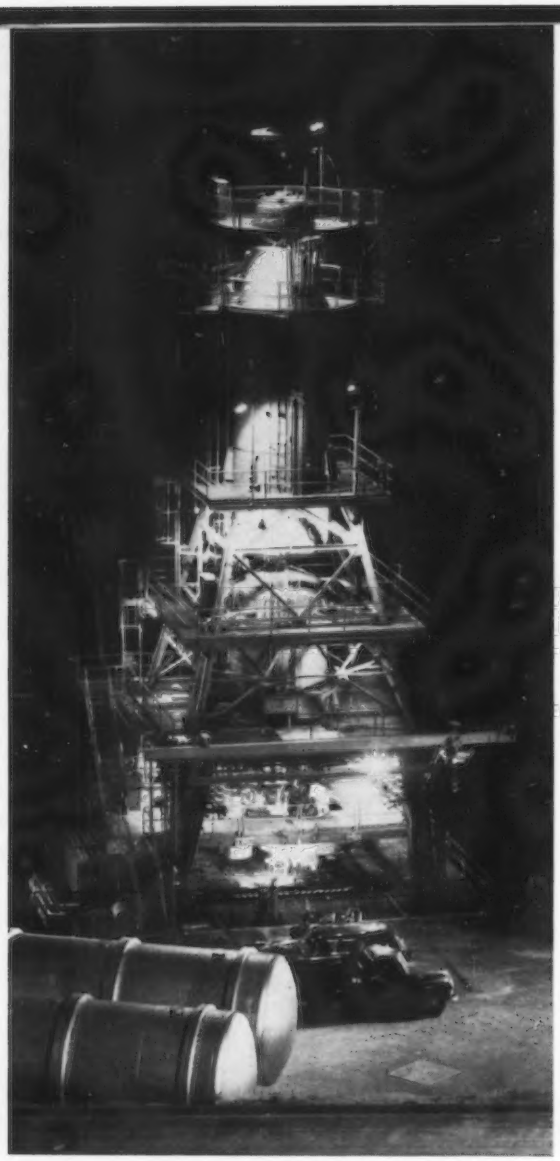


Several hundred feet of flexible hose are used on rocket engine test stand by North American Aviation at Santa Susana. Lightness is sacrificed to ruggedness in this application.

flexible hose—a status report

primes need hose with wider temp-pressure limits for next generation of vehicles; vendors need more funding to support R&D; better communications essential to solving problems

by **E. M. Ramberg**, v.p. of engineering, Titeflex Inc.

Flexibility is necessary in aircraft and missile plumbing where one or more of the following conditions prevail:

- One connection point moves relative to the other because of mechanical displacement—i.e., a landing gear cylinder in an airframe, or a gimballed rocket with a fixed pump.
- One connection point moves relative to another because of thermal expansion.
- Extreme vibration is an operational necessity.
- Piping must be "threaded" between obstacles.
- Manufacturing tolerances cannot be held tight enough to permit use of rigid piping.
- Components must be removed or replaced often.

General Types and Uses

Three general types of flexible piping are used.

- All-metal, braided stainless reinforcement over a stainless bellows (annular convolutions).
- Braided stainless over a Teflon tube.
- Braided stainless over various rubber tubes.

All-metal, flexible piping is used where temperatures are most severe, and where fluid contamination cannot be tolerated.

Braided stainless over Teflon core is used mainly in hydraulic lines. Teflon is limited to

environments from −65°F to 450°F. Below −65°F it looses most of its flexibility. Above 450°F it begins to decompose and give off fluorine gas.

Braided stainless over rubber is used a great deal in pnuematic lines. It is low in cost and resists damage. It cannot be used with liquid oxygen or above 275°F. It has exhibited a little more tendency to "flake" than Teflon core.

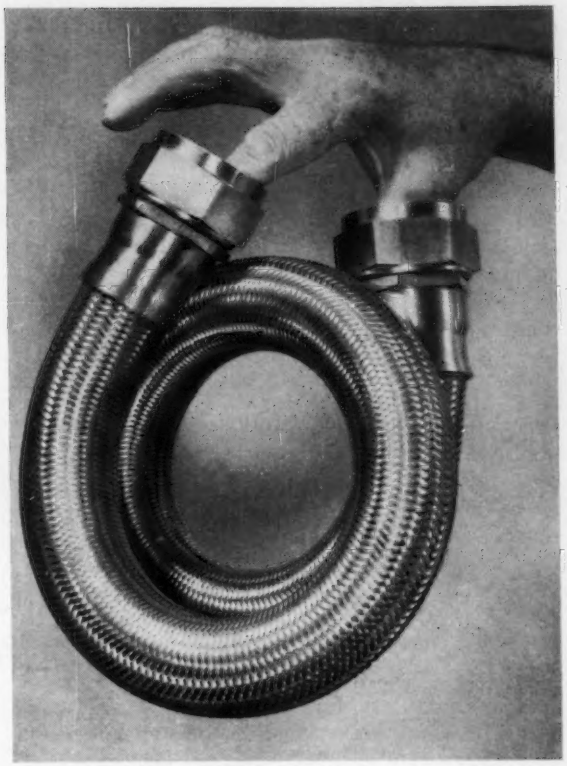
Intelligent Selection

Indiscriminate use of flexible hose can result in a less than optimum fluid system. Rigid assemblies should be used where possible to conserve space, reduce cost, and provide minimum system-pressure drop.

Where a small degree of flexibility is adequate, semi-rigid piping should be used. This is basically rigid tube with semi-convoluted sections at critical locations. The semi-convoluted sections have the same performance parameters as the rigid tubing sections and require no braid reinforcement.

Backup Systems

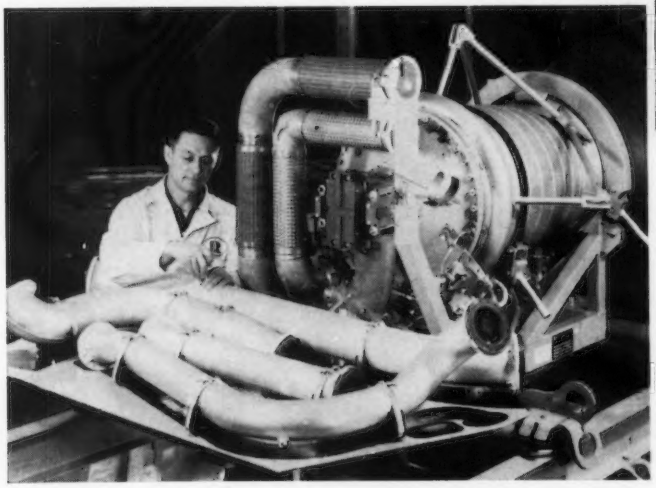
Unfortunately, performance parameters of presently-available hose just barely meet the requirements of some aircraft and missiles now being produced, and fall short of meeting the requirements of vehicles now on the drawing board or in prototype. Aircraft and missile designers, particularly those in hydraulics and propulsion, are expressing concern with the problems the flexible hose and piping industry is having in



Bend radius is an important feature. New convoluted Teflon core with stainless steel braid can be bent to 3½ times O.D. of the tube.

Hydraulic and pneumatic systems on the Jupiter engine also use braided flexible hose. Diameters, however, are smaller, i.e., up to 1 in.

Partially-assembled engine shows location of large-diameter flexible line. Materials of construction are various grades of 300 series stainless steel.



keeping abreast of the rapidly advancing aircraft and missile technology. Some of these designers have begun thinking in terms of ball joints, swivel joints, coiled rigid-tubing, machined manifolds, fluid-carrying structural members, and many other piping accessories in the event that the piping industry cannot provide flexible hose to meet increased requirements. One major airframe company, under the sponsorship of the military, is conducting a study program on methods of entirely eliminating piping. The aircraft and missiles designers see the hose and piping industry as reluctant to bear the development costs necessary to catch up and stay abreast.

A Challenge

If the hose manufacturers are to meet the challenge thrown up by the designers, several major technical advances must be accomplished quickly:

- IMPROVED FUNCTIONAL CHARACTERISTICS —flexible assemblies must be developed to operate at much higher pressures, carry highly corrosive fluids at high flow rates, and operate over much wider temperature ranges.
- WEIGHT REDUCTION—flexible assemblies must be developed which are lighter than present techniques permit. As

flexible hose . . . continued

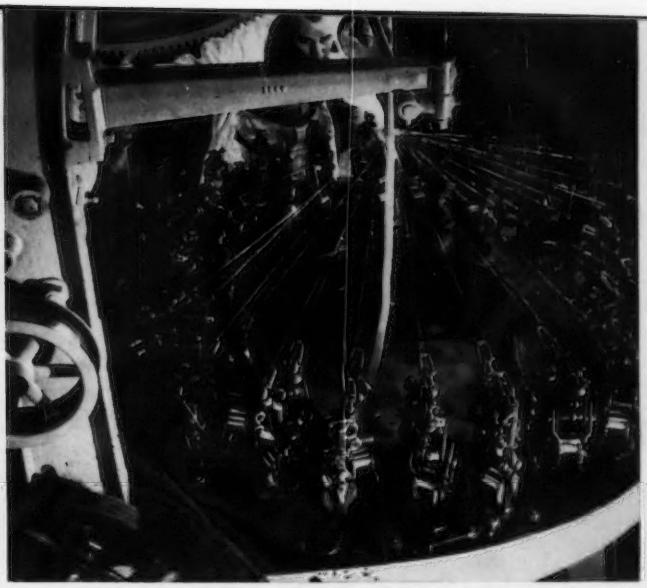
CHARACTERISTICS OF AIRCRAFT AND MISSILE PIPING

Category	Tubing Materials	Degree of Flexibility	Operating Pressure Range	Operating Temperature Range	Resistance to Corrosive Fluids	Suitability for Gas Conveyance	Tendency to Contaminate Conveyed Fluids	Resistance to Vibration	Resistance to Hydraulic Impulse or Surge	Tendency to Generate Loads on Attached Structure
Rigid Piping	Aluminum alloy	Low	full vacuum to 1000 psi [1]	−350°F to 400°F	fair	good	low	low	[3]fair	high
	Series 300 stainless	Low	full vacuum to 3000 psi [1]	−350°F to 1000°F	good	good	none	low	[3]fair	high
	AM350, 17-7PH stainless	Low	full vacuum to 4000 psi [1]	−350°F to 800°F	good	good	none	low	[3]fair	high
Semi-Rigid Piping	Aluminum alloy	Medium	full vacuum to 850 psi	−350°F to 400°F	fair	good	low	fair	good	medium
	Series 300 stainless	Medium	full vacuum to 3000 psi	−350°F to 1000°F	good	good	none	fair	good	medium
	AM350, 17-7PH stainless	Medium	full vacuum to 4000 psi	−350°F to 800°F	good	good	none	fair to good	good	medium
Flexible Piping	Rubber tube, wire braid reinforced	High in Small Sizes	full vacuum to 3000 psi	−40°F to 275°F	(depends on compound) fair	poor to good (depends on compound)	fair to high	good	good	low in small sizes
	Extruded Teflon tube, wire braid reinforced	High in Small Sizes	[2] full vacuum to 4000–6000 psi	−65°F to 450°F	excellent	fair	low	excellent	good to excellent	low in small sizes
	Convoluted Teflon tube, wire braid reinforced	High in All Sizes	partial vacuum to 1500 psi	−65°F to 400°F	excellent	fair to good	low	excellent	fair to good	low in all sizes
	Convoluted metal tube, wire braid reinforced	High in Small Sizes Medium in Large Sizes	full vacuum to 3000 psi[2]	−350°F to 1000°F	good	good	none	good	fair to poor	low in small sizes, medium in large sizes

1. Actual operating pressure depends on tube wall thickness.
2. High pressure ratings apply only to smaller sizes (¼"-½").
3. Depends on installation configuration.

Values represent accepted practice.
Table provided by author. Results do not necessarily represent Aircraft and Missiles Manufacturing's official opinion for completeness or accuracy.

Extreme quality control is a must in hose supplied to the aircraft and missiles industry. Fittings are a special problem; must be light, tight, and easily removable.



"Maypole" braiding principle is used in the manufacture of flexible hose at Titeflex Inc. Stainless steel (304) is being braided over convoluted Teflon core.

pressures and temperatures increase, the piping traditionally becomes heavier. This trend must be reversed.

- INCREASED RELIABILITY—modern missile and aircraft practice requires a previously unheard of degree of reliability in piping systems.

To fulfill these, a much closer working relationship than before is needed between designers and vendors; simply designing to specification is no longer adequate.

Hose manufacturers must fully exploit new materials, forming processes, joining processes, etc. New materials may even have to be developed.

Hose manufacturers must expend every effort to develop quality control techniques and testing techniques to provide the maximum degree of reliability. New test procedures must be developed and utilized. An example is combined environmental testing, i.e., simultaneous impulse, vibration, flexing, etc.

Prime contractors must realize the hose manufacturer sees ahead an era of relatively low volume on highly specialized products. He expects adequate development funds.

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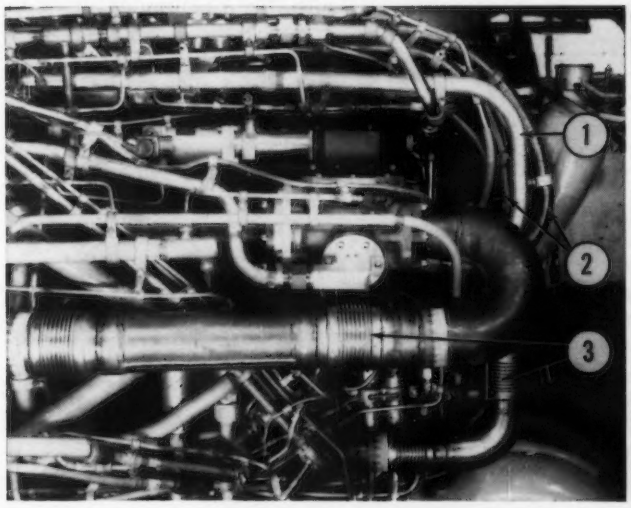
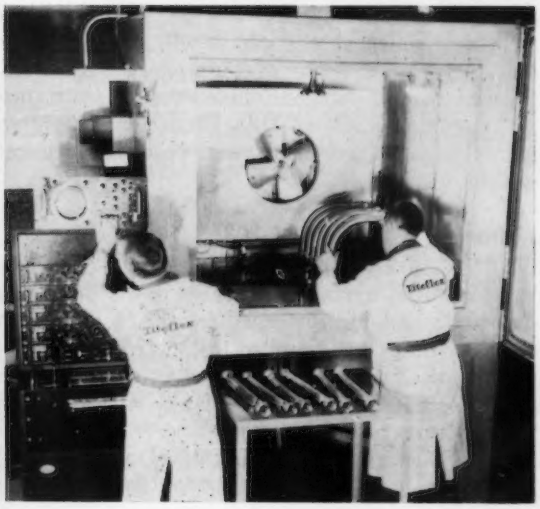
Reaction Motor's XLR-99 powerplant for X-15 uses rigid tubing (1), flexible monel over extruded Teflon (2), and "bare" convoluted 300 series stainless (3).



Environmental tests by hose manufacturers insure aircraft and missile companies that they are being supplied quality hose. Chamber shown can be used for temperature, pressure, and vibration tests.



flexible hose . . . continued

Turbojet Engines

Today, most engine manufacturers have standardized on braid-reinforced Teflon hose, or braid-reinforced convoluted metal for specific applications. Both are used in sizes of ¼ to ½ in. I.D. (nominal). Teflon hoses have been supplied by Aeroquip, Resistoflex, Titeflex, and others. Metal hoses have been supplied by Flexonics, Avica, Titeflex and others.

Engine usage has shown several areas of inadequacy in Teflon hose.

- Larger sizes, ¾ to 1½ in. I.D., have too little flexibility and too large a bend radius.
- Larger sizes have also shown some tendency to "kink" during assembly and disassembly.

Convoluting the Teflon core seems to have provided adequate solution to both problems.

The use of all-metal hose on jet engines has also shown up two problem areas. First, the fatigue life of the convoluted innercore has been inadequate. This is being handled by filling the spaces on the outside of the convolutions with high-temperature silicone sponge rubber, thereby dampening the destructive vibrations. A second problem has been the tendency of metal hose to be damaged by maintenance procedures in the field. This problem has been partially solved by better training of maintenance personnel.

Advanced engine models hold new problems. Ambient air temperatures can soon be expected to range from 600°F to 1200°F — fluid temperatures are climbing to the 600°F range. Fuel system pressures are rapidly approaching 2000 psi. Hydraulic system pressures on some engine models are already 400 psi. Fuel flows are heading toward values which will require 3 and 4-in. piping. The use of high energy fuels will present special problems in corrosion resistance. Accompanying all of these functional requirements is an ever increasing need for reduced weight.

Airframes, X-15, B-70, F-108

X-15 uses, to a great extent, Teflon-hose reinforced with stainless braid, in its 3000 psig hydraulic system. Sizes are mostly ¼ and ½ in. I.D. All hoses are impulse tested from 0 to 4500 psig. But, X-15 cannot be used as a criteron because some "production" planes already have higher-temperature systems.

F-108 and B-70, being developed by North American, have requirements for flexible piping that have not yet been met. Operating pressure is 4000 psig, fluid temperature reaches 450°F, and ambient temperatures are as high as 630°F. Impulse testing is done on this flexible hose from 0 to 6000 psi and from 2000 to 6000 psi with a 250,000 psig/sec rate of pressure rise.

Atomic-powered aircraft will bring another special brand of requirements.

Rocket Engines

Rocketdyne uses flexible hose extensively in engine, test stand, and launch pad. As an example, about 200 feet of hose are used on the test stand at Santa Susana. Test stand requirements are at variance with airborne requirements, since lightness is sacrificed to ruggedness. All test-stand hoses are rated at 3000 psi with a 4 to 1 safety factor.

When Rocketdyne designed its first gimballed engine, it was decided to keep the fuel pump fixed on the missile structure rather than mount it on the gimballed thrust chamber. This was done to reduce the mass being gimballed. A high-pressure, flexible feed-line was required between the pump outlet and the thrust chamber. All-metal hose with 4 in. I.D. and 1000-psi capability has been selected.

Another critical problem is the conveying of liquid oxygen at high pressures through large-diameter flexible ducts. Again, metal proves the best, since no plastic or rubber compounds presently available can be flexed at —350°F.

The Future, 1½ Million lb Thrust

Future requirements for flexible piping at Rocketdyne are extremely challenging. Truly flexible tubes will soon be required which can handle liquid oxygen and a variety of fuels at operating pressures up to 5000 psi. This piping will be required in diameters of 2 in. and above. Rocketdyne also foresees the need for vacuum-jacketed flexible hose for use with liquid helium and liquid hydrogen. Diameters of this hose would range from ¼ to 2 in.; operating pressures would reach 3000 psi and the jacket will have to hold a 0.5 micron vacuum. No products presently available meet these requirements.

For the F-1, 1½ million-lb thrust rocket engine chamber, testing requires 8, 12, and 14 in. I.D. flexible hose. Operating pressure is 3000 psig, and temperature requirement is for —300°F.

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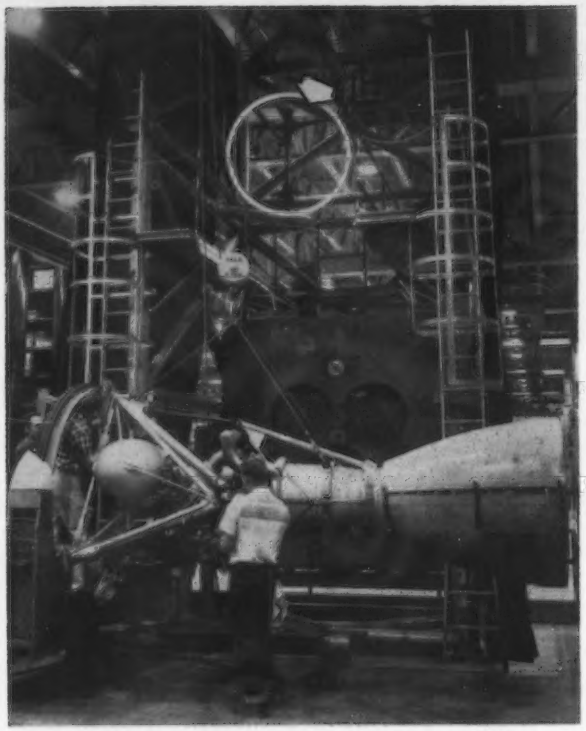
Circle 7 on Inquiry Card

thrust

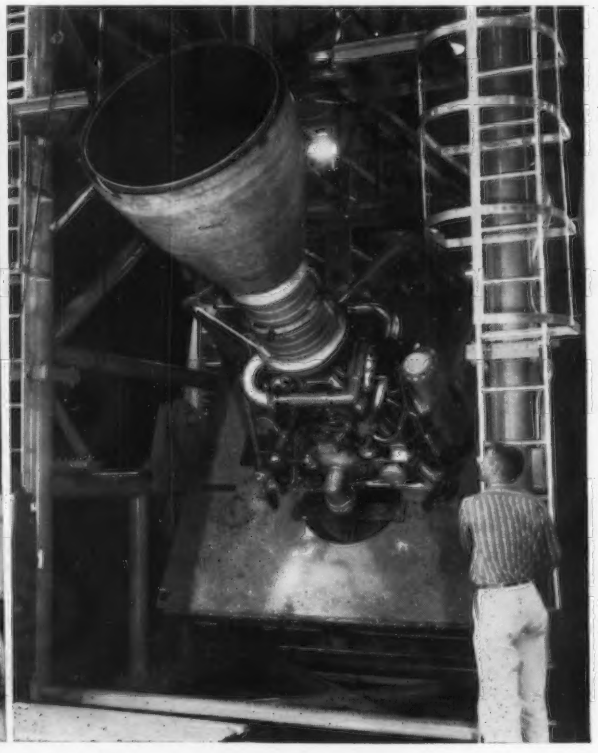
centerline of thrust chambers must match line perpendicular to plane of engine mounts within one-half degree



Workmen in assembly department roll engine up to the thrust alignment tower and are ready to fasten it to the tower table. "Spider" is circled.

Operator tightens attach point of engine to rotating table of tower. This assures proper location of attach holes and intakes, and helps determine length of adjustment of thrust actuator.

It takes about 16 min to slowly rotate the table and engine to perfect vertical.



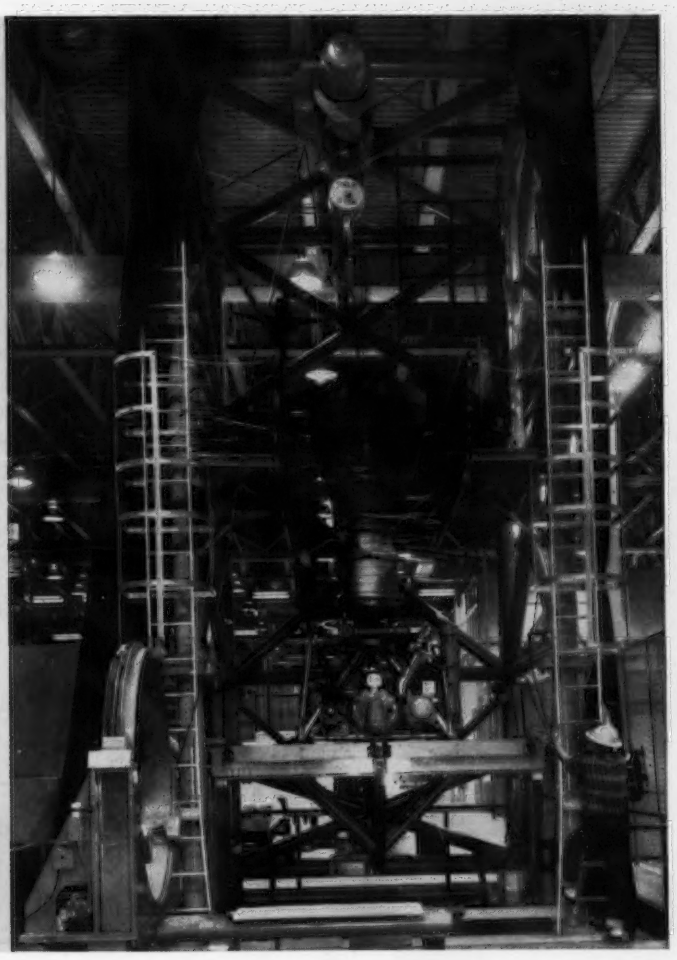
alignment in rockets

To determine the exact line of thrust on every rocket engine sent out of Rocketdyne Neosho, a large thrust alignment tower has been constructed. The alignment operation makes use of: an alignment "spider," one piece of which fits the throat and the other the exit nozzle of the thrust chamber; optical sighting and target devices; and, dummy gimbal actuator struts, which incorporate threaded adjustments for correcting angular deviations.

The angular procedure determines and adjusts the average geometric centerline of the chamber. This very nearly coincides with the thrust vector. The angle between geometric-centerline and a line perpendicular to the plane of the mounting pads cannot exceed ½ degree.

First Checks

First step is to insure that the line of sight of the optical apparatus coincides with the



Overall view shows size of thrust alignment tower. Engine is in position for locating the "spider."

Spider is lowered into upturned chamber; will be rotated to 24 different positions for readings to find geometrical center of chamber.

Two of five autocollimating scopes are shown. Readings tell where gimbal cross is located in relation to center of chamber, how high chamber is from base.

center of the mount pads. The table on which the engine is mounted must be horizontal. Proper centering of the mounting table follows, using the procedural specs.

Spider Manipulation

After checking out the apparatus, the master spider, several prongs on opposite ends of a rod, is positioned in the thrust chamber. One set of prongs contacts the throat of the chamber, the other set of prongs contacts the exit nozzle of the chamber.

When the spider is installed, the operator focuses his scope to infinity and turns on the illuminator for use as an auto-collimator. Then, using the threaded adjustments on the dummy gimbal actuator, the gimbal struts are lengthened or shortened until the observed error is at a minimum. The strut lengths are read and recorded. The spider is rotated about 15 deg and another such reading taken. The procedure is repeated for 24 readings.

The readings are averaged and the dummy actuator struts are adjusted to this average length. With the scope, the operator observes and records the magnitude and direction of deviation while the spider is rotated. The point readings so obtained are plotted on polar coordinate graph paper and averages are established for horizontal and vertical components of these points. An average point is established and is considered the final observation. The line passing vertically through this point and a line perpendicular to the plane of the engine mounting pads form the centerline deviation angle. It must not exceed ½ deg.

◆

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CONTROLS

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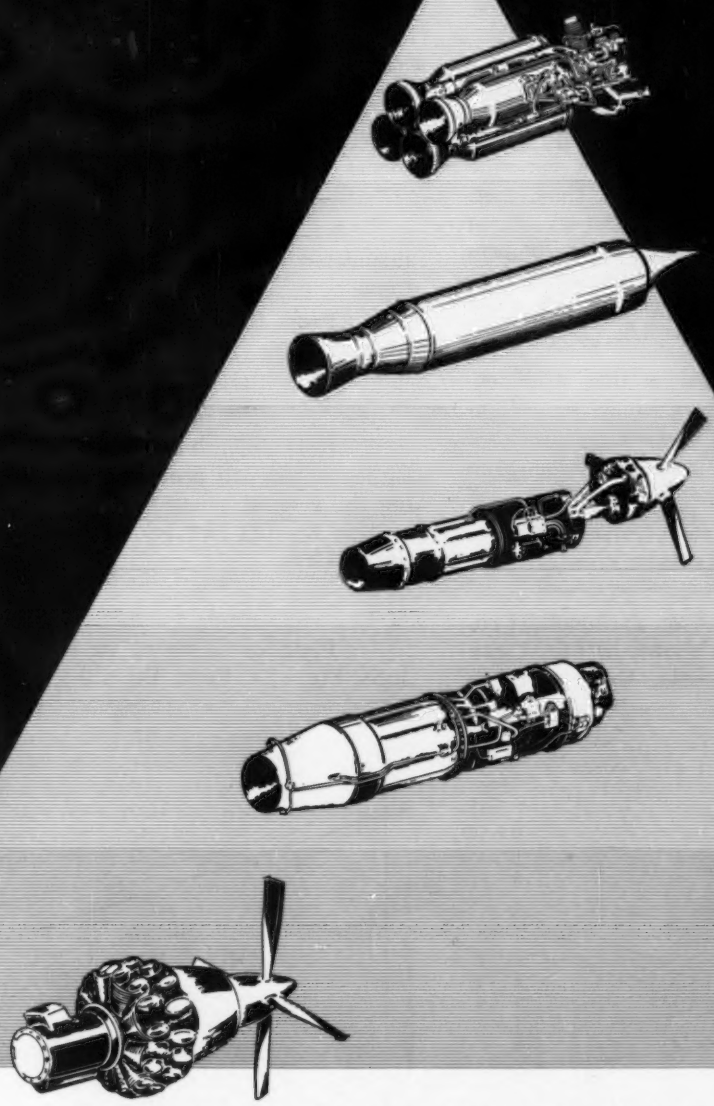

Bendix* has long been a leader in supplying controls and fuel systems for all types of aircraft engines. Today, Bendix is proving to be a natural for new challenges in related missile fields—on ram jets, rockets, nuclear power, and other advanced propulsion systems. So, when it comes to controls, remember that Bendix has the background—and is anxious to share it in solving your problems. *REG. U.S. PAT. OFF.

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Bendix AVIATION CORPORATION

Circle 8 on Inquiry Card

learning curves

a mathematical examination of one of industry's valuable "production control" yardsticks

by George H. Logan
North American Aviation Inc.

Time reduction curves, also called "learning curves," are highly valuable and versatile aids to the estimation of production time, cost, space, equipment, tooling, and manpower. These curves offer effective means for comparing production actual performance with predicted performance. The curves can be used to determine whether production is "in control."

Cumulated Average Man-Hours per Unit, Arithmetical Curve

A plant's production records for past-produced units is the starting point. The following are obtained:

t_1 = time to produce first unit, man-hours/unit
x_u = quantity of units produced at known dates
A_c = cumulated average man-hours/unit for x_u units

If A_c vs x_u is plotted on arithmetical coordinate paper, a curve as shown in Fig. 1 can be "faired" to the actual points. Experience has shown that this curve has an equation of the form:

$$A_c = \frac{t_1}{x_u^n} \qquad (1)$$

Cumulated Average Man-Hours Per Unit, Log-Log Curve

From Eq. 1:

$$(A_c)\,(x_u^n) = t_1$$
$$\log A_c + n \log x_u = \log t_1$$
$$\log A_c = -n \log x_u + \log t_1 \qquad (2)$$

It is apparent that plotting Eq. (2) on log-log paper will produce a straight line. Writing the general equation for a straight line and writing Eq. (2) just below it will show the identity of form.

$$y = mx + b$$
$$\log A_c = -n \log x_u + \log t_1$$

Plotting A_c vs x_u on log-log paper produces Fig. (2). From Eq. (2):

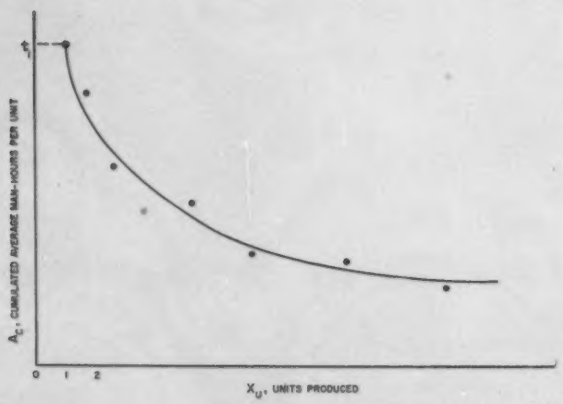

FIG. 1

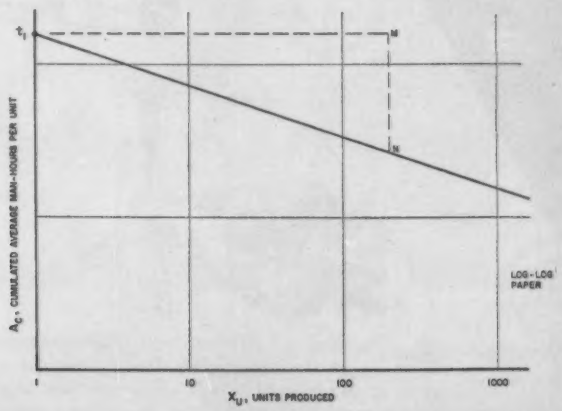

FIG. 2

$$n = \frac{\log t_1 - \log A_c}{\log x_u} \qquad (3)$$

Just as m is the slope of the line in the general equation for a straight line, so is —n the slope of the straight line in Fig. (2). Moreover:

$$n = \frac{\text{distance MN, inches}}{\text{distance } t_1 \text{ M, inches}} \qquad (4)$$

The feature of obtaining a straight line when A_c vs x_u is plotted on log-log paper is very useful. Merely t_1 and n are needed to define the straight line. The line is easily extrapolated to any value of x_u. The straight line simplifies comparison of impending A_c performance with past A_c performance.

Total Man-Hours vs Cumulated Units

Let T_c = cumulated man-hours, 1st through x_uth unit, inclusive.

$$T_c = (A_c)(x_u)$$
$$T_c = (t_1 x_u^{-n})(x_u)$$
$$T_c = t_1 x_u^{1-n} \qquad (5)$$
$$\log T_c = (1 - n) \log x_u + \log t_1 \qquad (6)$$

Values of T_c for various values of x_u can be computed from Eq. (6). It is simpler, however, to read the values from a plot. It is apparent that T_c vs x_u is a straight line on log-log paper, with slope (1−n). A plot of T_c vs. x_u and A_c vs x_u on one sheet is shown in Fig. 3.

Man-Hours per Individual Unit vs Cumulated Units

Let T_x = man-hours per individual unit for the x_uth unit.

For the x_u th unit: $T_c = t_1 x_u^{1-n}$

For the $(x_u - 1)$ th unit: $T_c = t_1 (x_u - 1)^{1-n}$

$$\therefore T_x = t_1 x_u^{1-n} - t_1 (x_u - 1)^{1-n}$$
$$T_x = t_1 [\, x_u^{1-n} - (x_u - 1)^{1-n} \qquad (7)$$

$$\log T_x = \log t_1 + \log [\, x_u^{1-n} - (x_u - 1)^{1-n} \,]$$
$$\log T_x = \log t_1 + \log (\, \text{antilog} [\, (1 - n)(\log x_u) \,] - \text{antilog} [\, (1 - n) \log (x_u - 1) \,] \,) \qquad (8)$$

Equations (7) and (8) are exact. If T_x vs x_u is plotted on log-log paper, the curve shown in Fig. 4 is obtained. It is noted that where x_u is greater than 10, the curve very closely approximates a straight light parallel to the A_c vs x_u curve. But Equations (7) and (8) are laborious to solve, and an approximate formula for T_x when x_u is greater than 10 will be derived. Recall that Eq. (1) is of the form:

$$y = \frac{t_1}{x^n}$$

Making some arbitrary assumptions:

$$y = \frac{10}{x^n} \qquad y = \frac{10}{(x - .5)^n} \qquad y = \frac{10}{(x - 1)^n}$$

If equations immediately above are plotted on log-log paper, the curves AB, CB, and DB of Fig. 5 are produced. It is observed that these curves substantially converge at x = 10, and when x is greater than 10 these curves are substantially coincident and straight. It is also noted that the shape of these curves is in close agreement with the A_c vs x_u curve of Fig. 4. Hence, a close approximation to Eq. (7) will be of the form:

$$y = \frac{a}{(x - b)^n} \qquad (9)$$

To evaluate a and b, first expand Eq. (7):

$$T_x = t_1 [\, x_u^{1-n} - (x_u - 1)^{1-n} \,] \qquad (7)$$

$$T_x = t_1 x^{1-n} \left[1 - \left(\frac{x_u - 1}{x_u} \right)^{1-n} \right]$$

$$T_x = t_1 x_u^{1-n} \left[1 - \left(1 - \frac{1}{x_u} \right)^{1-n} \right]$$

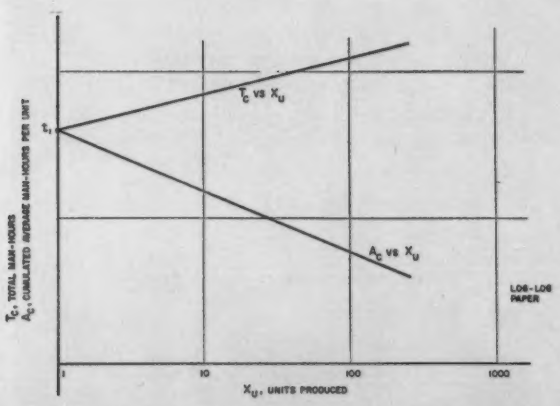

FIG. 3

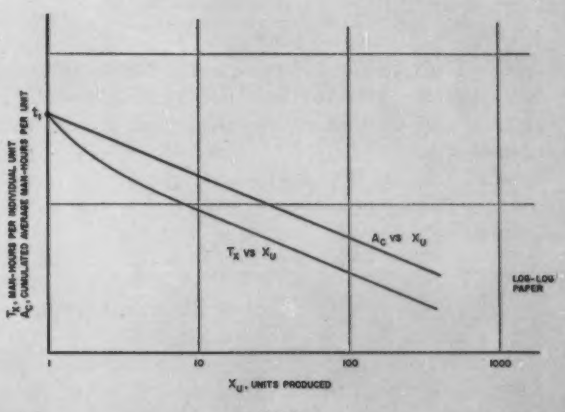

FIG. 4

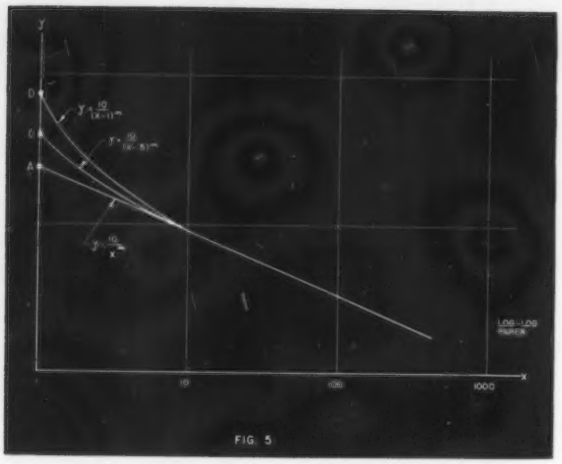

FIG. 5

$$T_x = t_1 x_u^{1-n} \left\{ 1 - \left[1 - \frac{(1-n)}{x_u} - \frac{(1-n)\,n}{x_u^2\,2!} - \frac{(1-n)\,(n)\,(n+1)}{x_u^3\,3!} - \cdots \right] \right\}$$

$$T_x = t_1 x_u^{1-n} \left[\frac{(1-n)}{x_u} + \frac{(1-n)\,n}{x_u^2\,2!} + \frac{(1-n)\,(n)\,(n+1)}{x_u^3\,3!} + \cdots \right]$$

$$T_x = t_1 x_u^{1-n} \left[\frac{1-n}{x_u} \right] \left[1 + \frac{n}{x_u^2\,2!} + \frac{(n)\,(n+1)}{x_u^3\,3!} + \cdots \right]$$

When x_u is greater than 10 the terms

$$\frac{n}{x_u^2\,2!}, \frac{(n)\,(n+1)}{x_u^3\,3!}, \ldots,$$

. . . become negligibly small. Hence:

$$T_x \cong \frac{t_1 x_u^{1-n}\,(1-n)}{x_u}$$

$$T_x \cong \frac{t_1\,(1-n)}{x_u^n} \qquad (10)$$

Thus, in Eq. (9) the quantity $a = t_1\,(1-n)$. Eq. (10) without further modification would be satisfactory enough if we never had to consider values of x_u less than 10. However, from Eq. (9) we can convert Eq. (10) into a form that is applicable for any value of x_u. We can write:

$$T_x \cong \frac{t_1\,(1-n)}{(x_u - b)^n} \qquad (11)$$

In Eq. (11), b shapes the curve properly for values of x_u less than 10; yet b has insignificant effect upon T_x when x_u is greater than 10. From actual experience with aircraft production records, b = .5 has been established for good fit. Hence:

$$T_x \cong \frac{t_1\,(1-n)}{(x_u - .5)^n} \qquad (12)$$

Percentage Designations for A_c vs x_u Curves

The particular A_c vs x_u curve plotted in Fig. 2 has a slope $-n = -.322$, and it is known as an "80% Curve." By this designation is meant that whenever x_u is doubled, the new value of A_c is 80% of its previous value. Similarly, for a "70% Curve," whenever x_u is doubled, the new value of A_c is 70% of its previous value. In general, let:

P = Percentage designation of an A_c vs x_u curve
x_i = A discrete value of x_u
When $x_u = x_i$, $A_c = t_1 / (x_i)^n$
When $x_u = 2x_i$, $A_c = t_1 / (2x_i)^n$

$$P = 100 \left[\frac{t_1}{(2x_i)^n} \div \frac{t_1}{x_i^n} \right]$$

$$P = 100 \left[\frac{1}{2} \right]^n \qquad (13)$$

$$\log P = \log 100 + n \log .5$$
$$\log P = 2 + n\,(-.3010)$$
$$P = \text{antilog}\,[2 + (n)\,(-.3010)] \qquad (14)$$

The 80% curve is of special interest. When x_u represents ships built, or x_w denotes pounds of aircraft structure completed, the actual-performance A_c vs x_u curve or A_c vs x_w curve is usually close to an 80% curve. When production records are sparse, and insufficient points are available to produce a value for n with confidence, it is customary to fit the available points to an 80% curve.

Shop Order Averages

Normally production is in successive blocks of units. The manufacture of these blocks of units is authorized by paper called *shop orders*. The cumulated average man hour per unit for the units in a *shop order* is equal to the cumulated time for the *shop order's* completion divided by the number of units in the *shop order*. Let:

A_{cs} = *Shop order* cumulated average man-hours per unit
x_a = Initial-unit serial number in a *shop order*
x_b = Final-unit serial number in a *shop order*
N_s = Total units in a *shop order*
T_{cs} = Total time for a *shop order* completion, man-hours
$N_s = x_b - (x_a - 1)$
$N_s = x_b - x_a + 1$ (15)

The total time for a *shop order's* completion will be:

$$T_{cs} = [T_c \text{ for } x_b] - [T_c \text{ for } (x_a - 1)] \qquad (16)$$

The cumulated average man-hours per unit for a *shop order* will be:

$$A_{cs} = T_{cs} / N_s \qquad (17)$$

$$A_{cs} = \frac{t_1 x_b^{1-n} - t_1 (x_a - 1)^{1-n}}{N_s}$$

$$A_{cs} = \frac{t_1 \left[x_b^{1-n} - (x_a - 1)^{1-n}\right]}{x_b - x_a + 1} \qquad (18)$$

Eq. (18) is exact. However, a simpler but satisfactory approximate formula for A_{cs} can be derived. Recall that:

$$T_x = \frac{t_1 (1 - n)}{(x_u - .5)^n} \qquad (12)$$

Now let $\bar{x}$ = the midpoint of a *shop order* for units x_a to x_b inclusive.

$$A_{cs} \cong \frac{t_1 (1 - n)}{(\bar{x} - .5)^n}$$

$$\text{But } \bar{x} = \frac{x_b + x_a}{2}$$

$$A_{cs} \cong \frac{t_1 (1 - n)}{\left(\frac{x_b + x_a}{2} - .5\right)^n}$$

$$A_{cs} \cong \frac{2^n t_1 (1 - n)}{(x_b + x_a - 1)^n} \qquad (19)$$

$$\log A_{cs} \cong n \log 2 + \log t_1 + \log (1 - n) - n \log (x_b + x_a - 1) \cdots\cdots (20)$$

Thus, when T_1 and n are known, Eq. (20) is useful for predicting the average time per unit for *shop orders*.

A plot of A_{cs} vs x_u for a hypothetical case is shown in Fig. 6. These curves are of course a succession of horizontal lines, each line extending between, and including, respective *shop order* values for x_a and x_b.

Cumulated Average Man-Hours per Pound vs Cumulated Pounds

The foregoing derivations show how to exhibit predicted-performance curves for a planned product, based upon past-performance, data (e.g. t_1, A_c, x_u, n) for a similar product. It has been assumed that: a point of similarity is that the planned product has essentially the same unit weight as the past-produced product.

But occasions arise wherein the planned product will have a unit weight that is significantly different from the past-produced product. Experience has shown that A_c varies not only

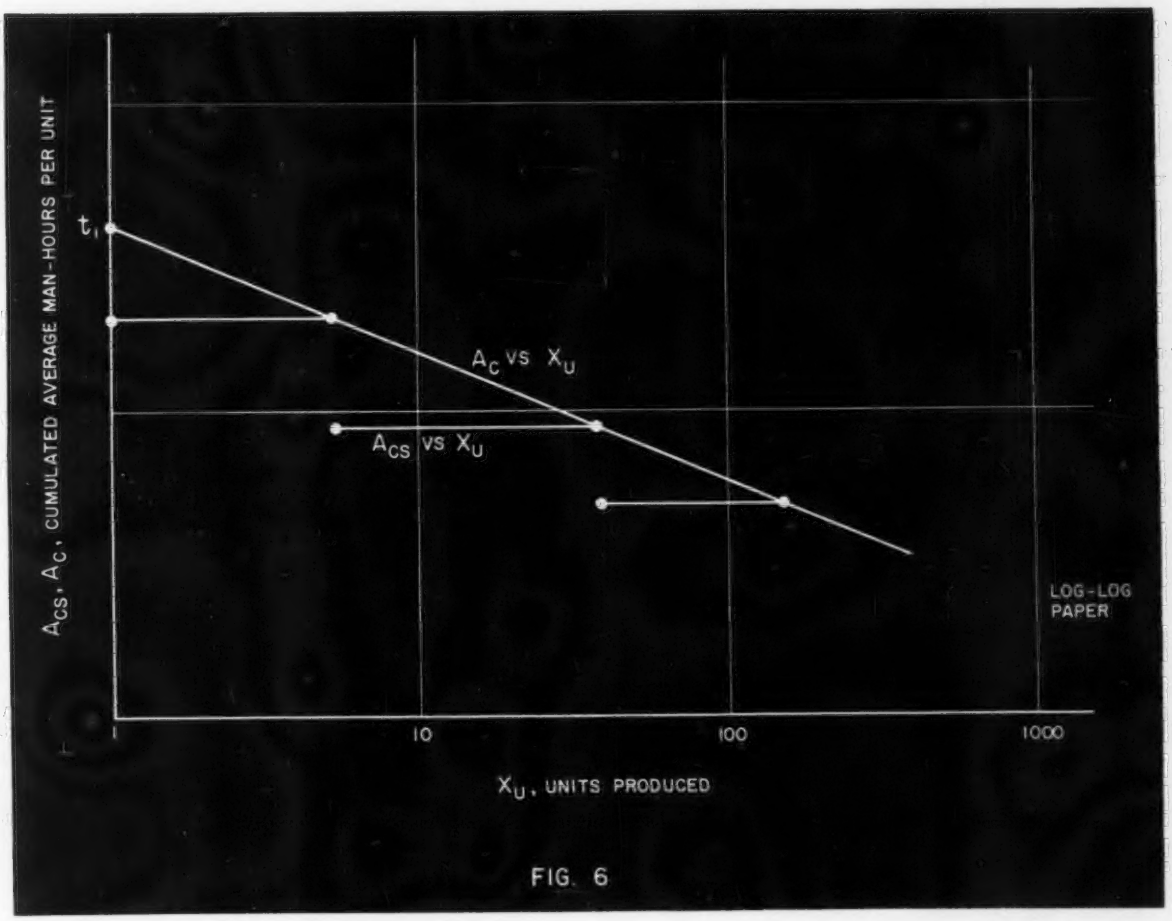

FIG. 6

with x_u, but also with the product's structural unit weight. In general, the higher the unit weight the larger A_c and T_c will be for a given number of units.

Assume that production records exist for several past produced models, of different unit weights. For any one of the models, let:

Y_c = Cumulated average man-hours per pound
x_w = Cumulated pounds
x_u = Cumulated units
W = Model's structural unit weight, pounds

$$x_w = (x_u)\ (W) \tag{21}$$

$$Y_c = (A_c)\ /\ (W) \tag{22}$$

From past records, values of A_c corresponding to discrete values of x_u, for each of the models, are tabulated. Conjugate values of x_w and Y_c are computed from Equations (21) and (22).

Experience has shown that when Y_c vs x_w is plotted on log-log paper, a curve fitted to the points will produce the straight line AB of Fig. 7. In other words, the cumulated average man-hours per *pound* for a given number of *cumulated pounds* is essentially the same for each of the models. Curve AB in Fig. 7 has the equation:

$$Y_c = K\ x_w^{-n} \tag{23}$$

The slope, —n, of curve AB is obtainable by the method previously given. The constant K in Eq. (23) is the intercept on the Y_c axis when $x_w = 1$ pound. The constant K is readily obtained by substituting known values of Y_c, x_w, and n in Eq. (23).

To demonstrate the value of curve AB in Fig. 7, consider that we have a planned model of any known structural unit weight. The cumulated pounds for specific values of x_u are computed. The curve AB is entered at the abscissa,

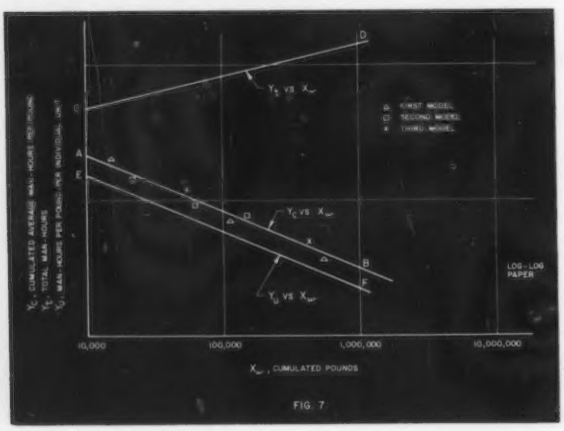

FIG. 7

and the values of Y_c found are divided by W, giving A_c. Thus, any number of points on the A_c vs x_u curve are obtained. The A_c vs x_u curve is plotted, and the corresponding T_c vs x_u curve, T_x vs x_u curve and the A_{cs} vs x_u curve can be developed by the methods previously given.

Total Man-Hours vs Cumulated Pounds

The availability of curve AB in Figure 7 makes it possible to plot curve CD in Fig. 7, total man-hours vs cumulated pounds. Let:

Y_t = total man-hours

$$Y_t = (Y_c)\ (x_w)$$

$$Y_t = (K\ x_w^{-n})\ (x_w)$$

$$Y_t = K\ x_w^{1-n} \tag{24}$$

Eq. (24) describes curve CD. To use curve CD for estimating a planned model, the values of x_w that are of interest are computed; and predicted total man-hours, Y_t, are read directly.

Man-Hours per Pound per Individual Unit vs Cumulated Pounds

The availability of the parameters K and n from curve AB in Figure 7 makes it possible to plot curve EF in Figure 7, man-hours per pound per individual unit vs cumulated pounds. Let:

Y_u = man-hours per pound per individual unit

For the x_uth unit:

$$Y_t = K\ x_w^{1-n}$$

$$Y_t = K\ [x_u\ W]^{1-n}$$

For the $(x_u - 1)$ th unit:

$$Y_u = K\ [\ (x_u - 1)\ W]^{1-n}$$

For Y_u at x_u:

$$Y_u = K\ [x_u\ W]^{1-n} - K\ [\ (x_u - 1)\ W]^{1-n}$$

$$Y_u = KW^{1-n}\ [x_u^{1-n} - (x_u - 1)^{1-n}] \tag{25}$$

We have previously shown that:

$$[x_u^{1-n} - (x_u - 1)^{1-n}] \cong \frac{(1-n)}{x_u^{n}}$$

$$\therefore\ Y_u \cong \frac{KW^{1-n}\ (1-n)}{x_u^{n}}$$

$$Y_u \cong \frac{KWW^{-n}\ (1-n)}{x_u^{n}}$$

$$Y_u \cong \frac{KW\ (1-n)}{x_u^{n}\ W^{n}}$$

$$Y_u \cong \frac{KW\ (1-n)}{x_w^{n}}$$

For aircraft, even when x_u is as small as 1, the quantity x_w will be much greater than 10. Hence Eq. (26), although strictly speaking an approximation, is thoroughly satisfactory for any aircraft application.

Based upon these fundamentals many other highly useful corollary charts and equations can be derived. Certainly important among these will be the conversion of man-hours to dollars cost.

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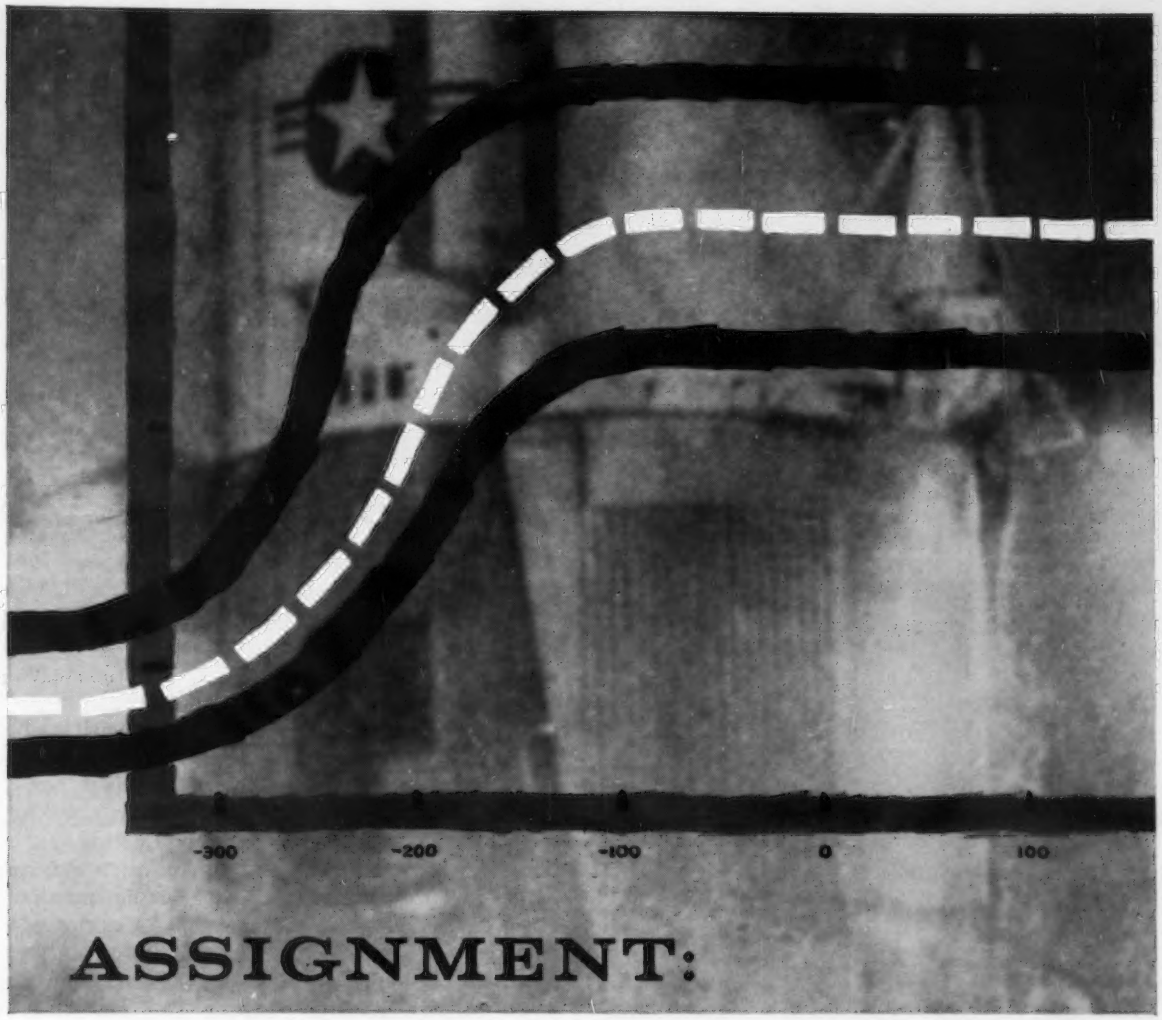

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Misco Precision Casting Co.

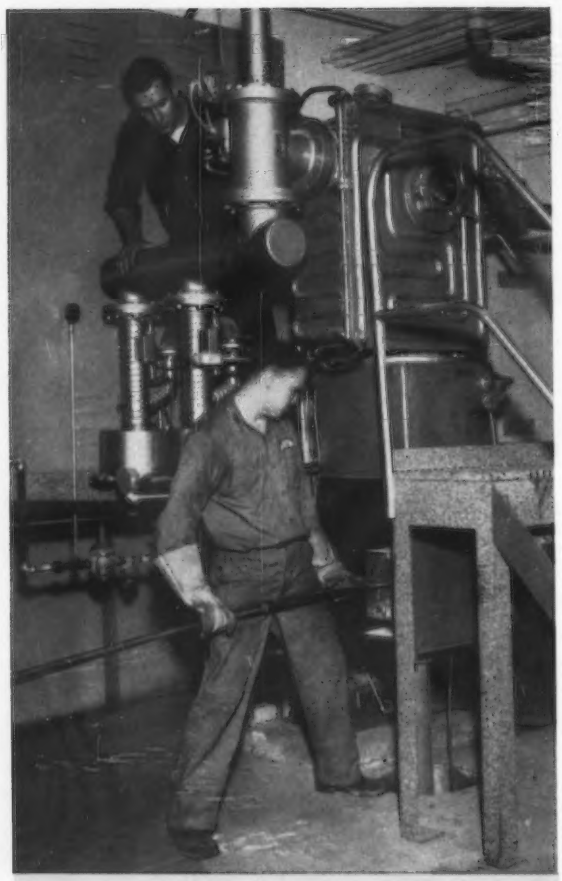


Fig. 1. Vacuum furnace is used for remelting billets. Operator is shown charging furnace by placing mold on small pneumatic lift.

The most important objective in working toward higher engine outputs, is attaining higher operating temperatures. Thus, metallurgists have been called upon to produce alloys which will withstand, and perform at, these elevated temperatures. Remarkable improvements in physical properties have been achieved with modified nickel, cobalt, or iron base materials.

The very nature of these materials, however, (high strength at high temperature) makes them difficult to forge or machine. Casting, particularly investment casting, has therefore gained wide acceptance in producing turbine blades, vanes, nozzles, and elbows. A further refinement vacuum melting, has become necessary to produce specified physicals and casting quality.

Misco Precision Casting Co. met these challenges with improvements in two areas of great importance to the art of casting.

- A technique for making molds as a monolithic ceramic shell, MonoShell process.
- A furnace for vacuum investment casting.

MonoShell Process

Instead of investing a massive mold around a wax pattern, the cluster is dipped into a ceramic slurry, stuccoed, and dried in the MonoShell process. (Wax patterns and clusters are made by conventional techniques.) The dipping process is repeated a number of times until a ¼-in. ceramic shell is built up around the entire wax cluster. Dewaxing is accomplished by firing the shell to 1900°F. Upon cooling to room temperature, the shell can be used immediately or stored. These molds can be used more flexibly than can invested molds. For instance, preheat

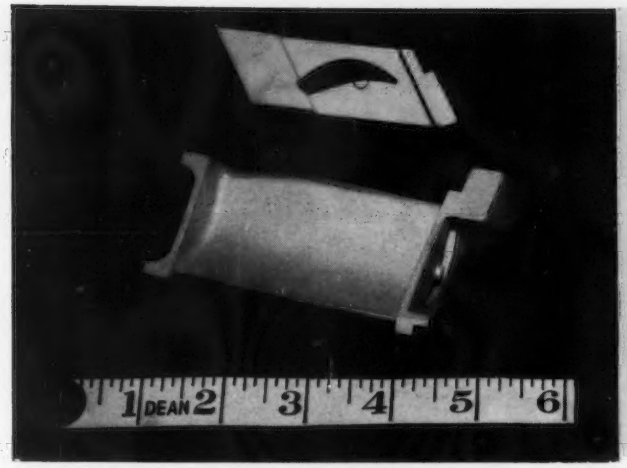


Fig. 2. Hollow-vane castings of WI-52 alloy (cobalt-tungsten) are made for Pratt & Whitney. Properties of vacuum processed material are compared with same material processed by other means in Fig. 3.

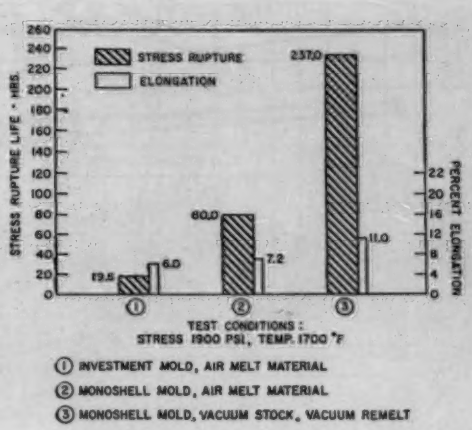


Fig. 3. This chart shows improvements achieved with vacuum processed WI-52 stock. Shaded bar gives stress rupture life in hours, other gives elongation.

of the shells can vary from RT to 1900°F. They can also be surrounded by insulating backup material. Or, they can receive the molten metal without backup, where rapid cooling is desired.

The ceramic materials used are generally "more refractory" than the type used in silica investment molds. Surface quality of the casting is enhanced by inhibiting many of the metal-mold reactions.

Vacuum Furnace

The vacuum furnace used by Misco was developed by F. J. Stokes Corp. As shown in Fig. 1, this unit includes charging locks for the molds, and for the remelt stock. It is designed for remelt only, i.e., it is not intended for use in refining metal.

The melting chamber is rectangular, and is encircled by water cooling-coils. It contains a 17 lb induction melting furnace, powered by a 30 kw motor generator set.

As illustrated, the mold chamber is below the melting chamber. The operator can be seen placing a mold into position on the pneumatic lift. In operation, the door is then closed and the chamber evacuated by a vacuum pump. A flopper valve between the chambers is opened and the mold is raised to pouring position. When the proper temperature is reached, the melting furnace is completely tilted to give a fast, well con-

Fig. 4. Alloy A-286 was used in fabricating this series of strut-structural members for General Electric Co. Physicals are listed in Table 1.

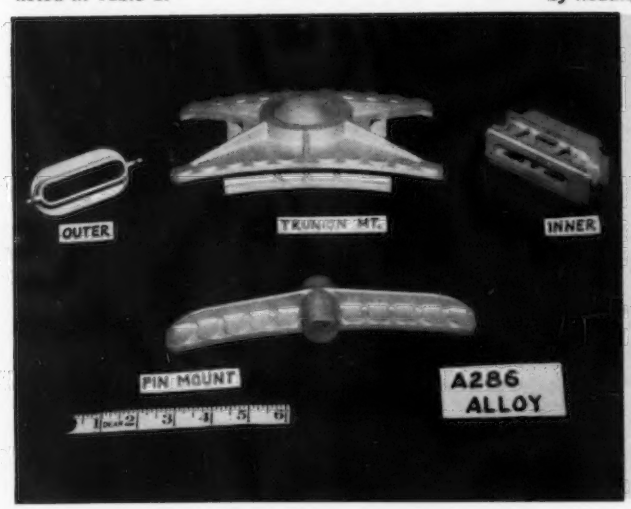


Table 1. Results of various testing laboratories are compared with original GE specification. All test specimens were machined from oversize casting, heat treated at 2000°F (in argon) 2 hr, then oil quenched. Treatment at 1650°F for two hr, and air cooling; followed by heating to 1300°F for 16 hr, and aircooling, complete the cycle

Testing Lab.	Note	Ultimate Tensile	Yield 0.2% Offset	Yield 0.2% Offset	% Elong.	Reduction of Area-%
—	G.E. Spec.	110,000	75,000	60,000	10	20.0
G. E.	*	108,680	86,000	75,900	13.1	20.9
Misco	**	113,800	89,500	70,900	12.5	26.3
U of M	***	108,700	86,700	74,000	9.3	14.5
Met-Cut	****	103,500	85,400	74,800	13.2	22.2

Note: * Average of 10 tests.
** Average of 9 tests.
*** Average of 3 tests.
**** Average of 4 tests.

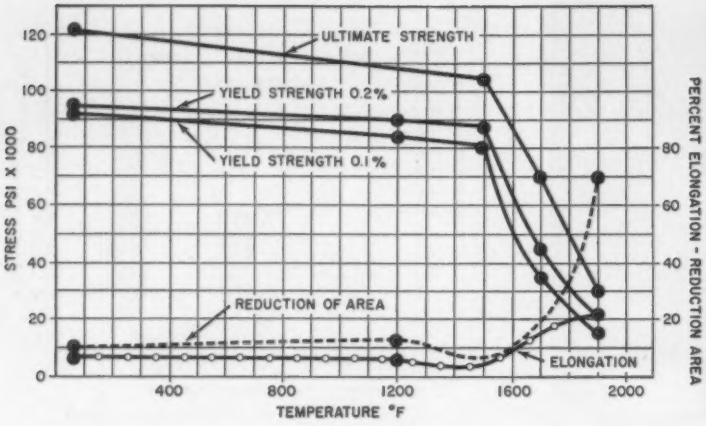
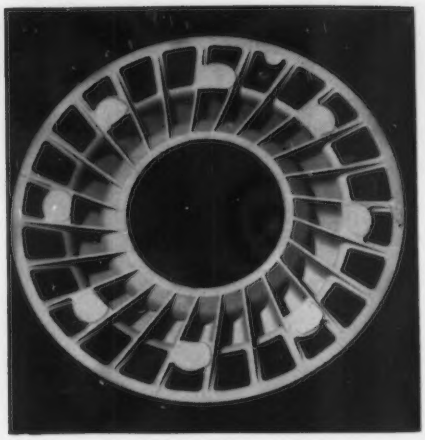


Fig. 5. MECHANICAL PROPERTIES of INCONEL 713 vacuum melt primary, and vacuum cast by MonoShell.



Rocket turbine nozzle is vacuum cast of special high temp alloy for Reaction Motors.

"hot" engine . . . continued

Inconel 713 is used in casting turbine blades for Orenda Engines Ltd. Mechanicals are shown in Fig 5.

trolled filling of the mold cavity. Only enough metal is melted to fill the cavity.

The unit was designed and is used as a production tool. An average of 4 molds/hr can be processed.

Casting Alloy A-286

The series of castings shown in Fig. 4 are strut-structural members processed for the General Electric Co. Alloy A-286, an iron-base, aluminum-titanium modified material, is employed. Early experiments with this material, processed by air melting or argon melting, produced poor surface quality and physical properties. The aluminum-titanium present in the material caused oxide stringers on the surface of the casting. Zyglo inspection revealed these as cause for reject.

Vacuum MonoShell casting corrected these conditions. Typical properties obtained by vacuum casting A-286 are listed in Table 1.

Turbine Blade-Inconel 713

Turbine blades in Inconel 713 have been produced for Orenda Engines Ltd. Part configuration is illustrated. This alloy has a nickel base and is also modified with aluminum and titanium. Oxide coatings similar to those in the A-286 alloy appeared in air melted and argon melted castings. Requirements of 30 hr at 1700°F and 30,000 psi stress were difficult to meet. Reject rate at Zyglo inspection was excessive until vacuum melting was employed. The average part can now be run for 60 hr under the same conditions of temperature and pressure. The mechanical properties of the vacuum processed material are shown in Figure 5.

Rocket Turbine Nozzle

A large investment casting being produced for Reaction Motors Div. of Thiokol Chemical Corp. is used as a rocket turbine nozzle. It is approximately 9 in. in diam, and weighs 4 lb. The material of construction is a nickel base, aluminum - titanium modified alloy. Castability is similar to Inconel 713. This component shows improvement in surface quality and physical properies when vacuum cast. Typical strength values are:

Heat Treat Condition	Test Temp.	Ultimate Tensile	Yield 0.2% Offset	% Elongation
Note	R.T.	122,350	97,100	8.0
Note	1200° F	106,100	86,300	12.0
Note	1500° F	88,100	74,800	6.0

Note— Heat Treatment
4 hours — 1975° F — air cool
4 hours — 1550° F — air cool
16 hours — 1400° F

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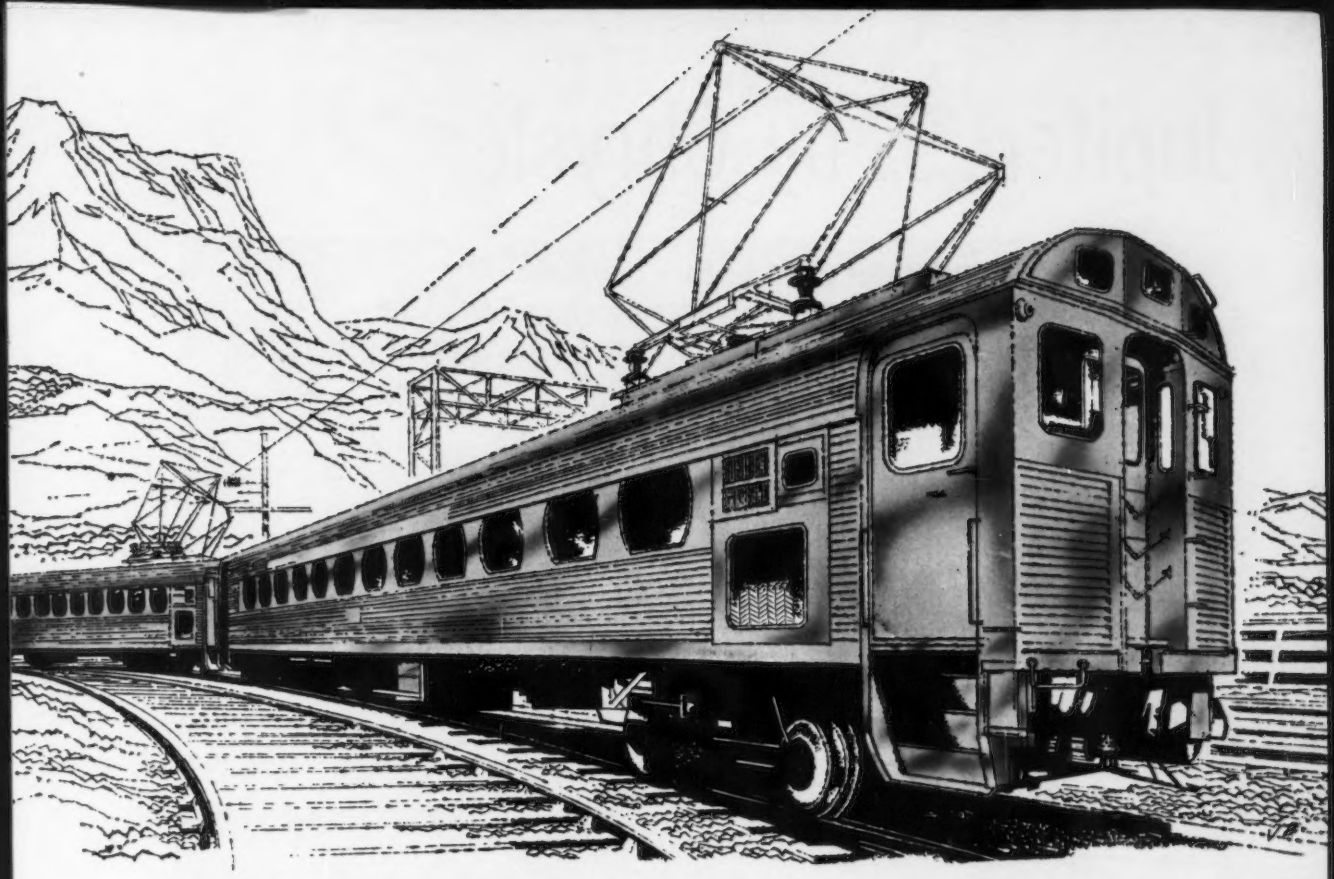

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Circle 10 on Inquiry Card

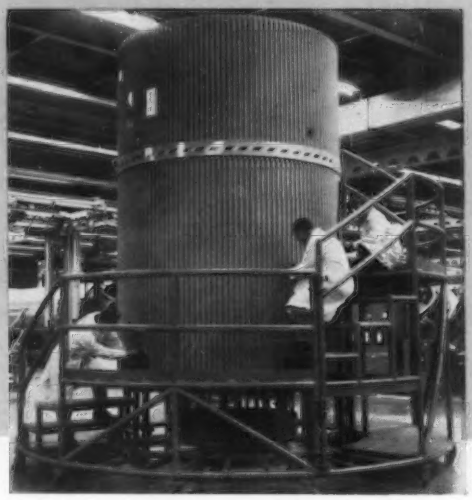
Jupiter . . . by Chrysler

IRBM designed in four sections; frequency of "engineering changes" requires close coordination of design and production to maintain schedules

by John S. Sheldon
Chrysler Corp.
Missile Div.

Center section is made of 7 barrels, all AA5086 wrought, non-heat-treatable sheet. Sample weld is submitted to quality control before production run starts.

Tail section is comprised of Z-ring supports, and corrugated longeron panels. This all-riveted structure houses the powerplant.



Missile parts must be manufactured on a tight time schedule and within a definite cost limitation. Integration of design, quality control and production personnel must be developed to a higher degree than in any other industry, and must be maintained on a daily basis. Chrysler's Missile Div. conditioned itself to these basic precepts before starting on Jupiter production.

Chrysler's production engineers expect, and accept, that they will be required to make major changes in missiles just starting production, as well as in those that are well along in the production system. In each case, no change in delivery schedule is tolerated, and sight is never lost of the fact that shortening of lead time is most important to the customer.

Obsolete Every 200 Sec.

One of the manufacturing problems in such a system is to establish a workable schedule. The basic scheduling philosophy is in its very nature, however, not wholly compatible with

Double end routing machine is used to "square" and accurately size barrel assemblies. Six barrels are of 0.091 in. sheet, other is of 0.125 in. sheet.

the engineering magnitude of the product. Operations are performed in parallel, wherever possible. This does not permit the completion of one element prior to the start of another element.

As an example of the effect this whole system has on production—over a one-year period, Chrysler processed about 160,000 releases and changes. This is an average of one every 200 sec, 24 hr a day, continuing through a 365-day working year. This means that a new design was being created, or an old being changed every 200 sec.

The Jupiter Structure

Jupiter IRBM is broken down into four main sections:

- Tail section
- Center section
- Aft section
- Nose section

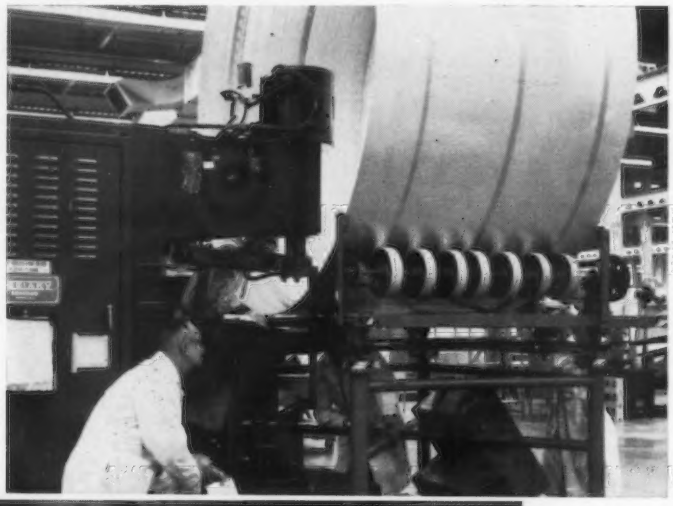
The tail section is similar in many respects to a section of aircraft fuselage. It is comprised of an outer skin, reinforced with Z-rings and longeron panel assemblies. These are all riveted together to form the structure which houses the main power plant.

The center section has a dual function. First, when coupled with the tail, it makes up the booster or main stage of Jupiter. Second, and most important, it acts as a storage tank for the liquid propellants. The center section is made from rolled semi-circular skins, butt welded together to make one large tank. A bulkhead assembly is welded to each end. The liquid oxygen

Jupiter . . . continued

and fuel are separated by a center bulkhead welded to the inner surface of the skin.

The main skin assemblies, or "barrels," consist of two semi-circular segments which have been mechanically milled on the inside surface to reduce weight. They are accurately trimmed, both for length and width, and butt welded automatically by the TIG process (tungsten-inert-gas). Every linear inch of the two butt welds in the resulting cylinder is X-rayed. Z-rings are later installed by spot welding. These act as structural members. After the installation of the Z-rings, the "barrel" assembly is placed in a double-end routing machine which simultaneously routes each end of the cylinder to an exact length. Three of these "barrel" assemblies carry the liquid-separating bulkheads. Bulkheads are drawn into position inside the skins and fillet welded by a semi-automatic welding process. The bulkhead assemblies are fabricated on separate welding fixtures by circumferentially welding a sectioned cone to a welded knuckle as-



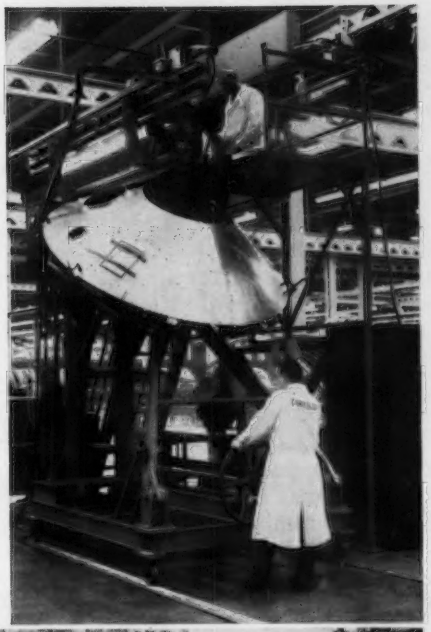
Z-rings of 6061-T6 are spot welded to barrel sections for strength. Welds are at 1 in. intervals. 200kva Sciaky is used. Dekatron unit counts and times welds.

Progressive welding fixture is used to join barrels that make up center section. Man on extreme right uses optical equipment to insure no "run out" is built in.

sembly. Once again, all welds are one hundred percent X-rayed. When the "barrel" assemblies have been completed they are placed in a huge circumferential welding fixture where they are butt welded into one large cylinder. The circumferential welds are done by automatic welding using the MIG process (metal-to-inert-gas).

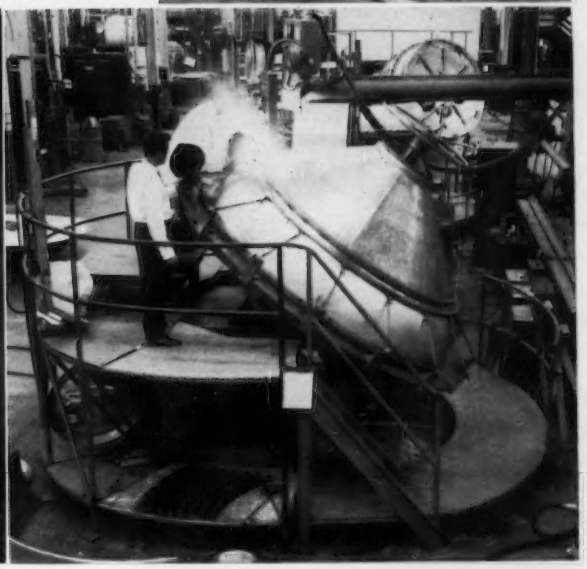
Quality Control

While the welding of the barrel assemblies is being conducted, a constant watch is maintained optically to assure that no "run out" is built into the finished product. Circumferential welding of the center section is an extremely



Bulkheads which separate kerosene from lox in integral tankage are dome or cone shaped. Longitudinal weld is shown being effected in semi-automatic welder.

Air tool and special fixture are used to route out a flange hole in the cone section of the bulkhead. Knuckle will be welded to lower part of cone.



Circumferential weld of 0.156 in.-thick knuckles and cones is effected with Linde Sigma head on Lewis boom. Weld rate is 35 in./min at 25v and 210 amp.

Tail section and center section are not joined by welding. Here, large Carlton drill is used to provide inner attach holes in lower part of center section.

delicate process. Careful control must be maintained as to fit, cleanliness, back-up and outside pressure, wire-feed speed, welding voltage, welding current, and line voltage. Before any center-section production weld is made, a sample weld must be done on coupons of like materials and gauges. Quality Control performs radiographic, and physical examination of the coupons. After approval, all automatic welding machines are set to duplicate the good weld for the production run.

After the center section satisfactorily passes the X-ray requirements for circumferential welds, it is placed in another large fixture for the attachment of the tail assembly. This fixture is similar in size and function to the circumferential welding fixture. The tail is attached to the center section by riveting and is very closely positioned optically to make sure that the two assemblies are in perfect alignment.

Hydrostatic Test

After tail and center section have been joined to form a booster assembly, it is placed in a vertical position and hydrostatically tested for leaks in the outer skin welds or in the bulkhead welded joints. Leaks are detected by adding a dye penetrant to the water and examining each weld with a black light. Should a leak occur, the liquids are removed, repairs made, and the entire process repeated.

The Aft section has a configuration of a large frustrum, and is made of a combined riveted and welded construction. The skirt section is made of magnesium alloy, and is separated from the instrument compartment by a pressure bulkhead. The instrument compartment must be pressure tight.

Assembly

Before installing the powerplant, hundreds of components parts are fabricated, sub-assembled, tested, and assembled to the engine. After completion of the powerplant assembly, another reliability check is made on all mechanical, and electrical parts using the missile's electrical and pneumatic systems. The completed power plant is then installed in the tail and aligned with the aid of optical equipment. Connection of the engine to the center section and the installation of control equipment follows with the same accuracy and care used in the assembly of the engine.

With the completion of booster unit, aft unit, and nose, these units are then assembled into one; again, optical instruments insure perfect alignment.

Upon connection of all electrical and mechanical units, the missile is complete. Final checkout of the entire system follows. This hydraulic, pneumatic and electrical functional checkout is so complete that the missile goes through a count-down and a simulated flight.

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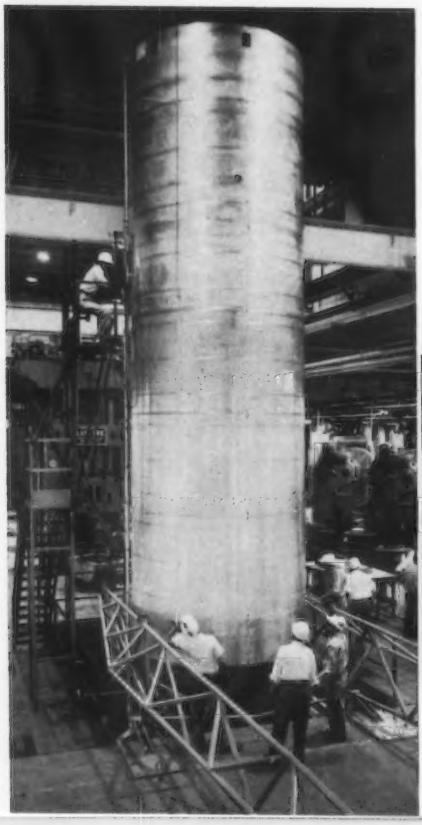
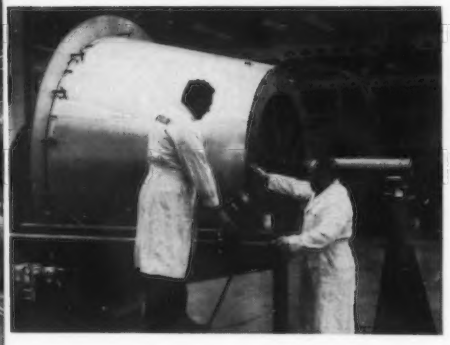
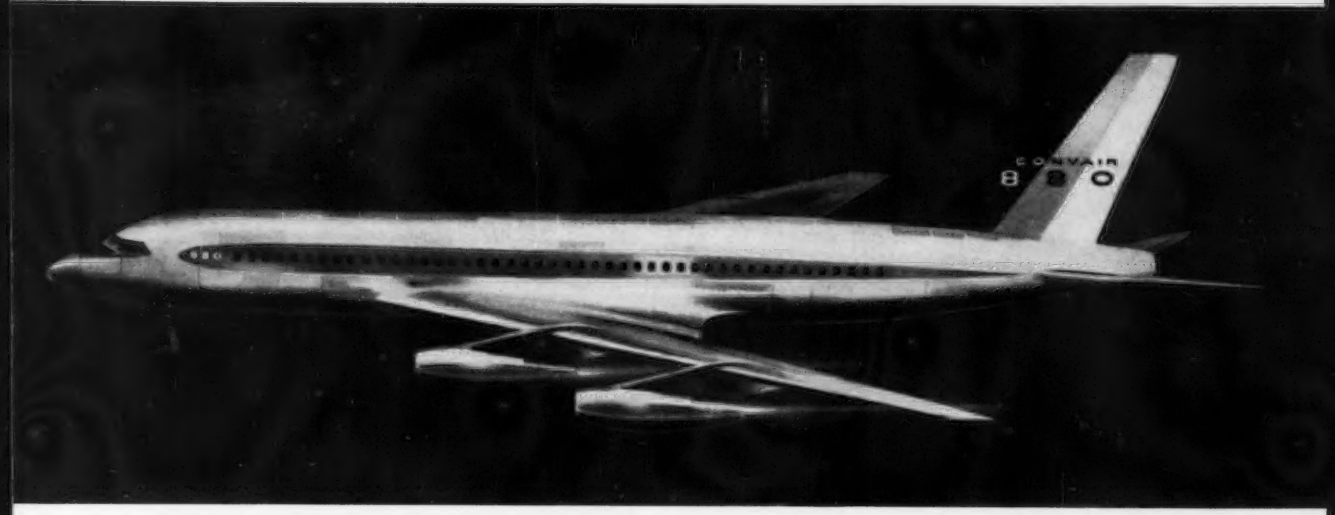
By adding dye penetrant to water solution, and examining all weldments with black light, during hydrostatic testing, leak detection is made reliable.





Aft section is a large frustrum. It is a combination welded-riveted structure. Welded section shown here forms pressure tight instrument compartment.

Boeing 707 and Convair 880 rely on Chatham power conversion units



THE Boeing 707 and Convair 880 represent the very latest developments in luxurious air travel. Standard equipment on both includes power conversion units made by Chatham—world's number one maker of power supplies for missiles and military and commercial aircraft.

Chatham airborne conversion equipment features minimum size and weight. Because Chatham makes its own solid-state components—silicon, germanium, selenium—our designers are not limited by available stock and can tailor components to fit power supply design, shaving excess inches and ounces.

Reliability is unsurpassed. Chatham power supplies show a uniformly high performance record in aircraft of all types and each unit reflects a long-standing reputation for trustworthy electronic equipment.

Chatham has many power supplies in stock, ready to go . . . or will design and produce a unit to your specifications. Either way, you can fill any power conversion need—AC to DC, DC to DC, DC to AC—with an efficient, high reliability unit made by Chatham. Contact: Chatham Electronics, Division of Tung-Sol Electric Inc., Livingston, New Jersey.

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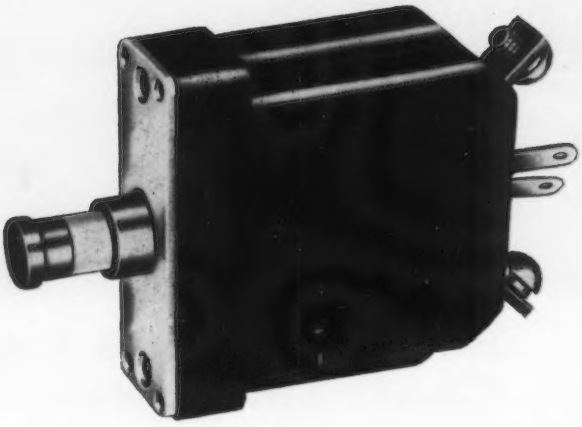
Circle 11 on Inquiry Card

circuit-breaker simulator

by **Newell McCartney,** senior engineer
The Martin Co.
B. A. Bosher, application engineer
Metals and Control Corp., Spencer Div.



D-6735-2 circuit-breaker simulator operates by 0.3 amp current.

Modification of a Standard Manual Control (Klixon D6753-1) now makes it possible to simulate circuit breaker operation using extremely low power levels. Without changing body size this control has been redesigned to incorporate an electrically-isolated magnetic tripping circuit. Earlier, it was necessary to use 5 amp circuit breakers and pass an overload current, of 15 or 20 amp, through the tripping circuit to give quick, consistent trips. The tripping of the new circuit breaker simulator can now be accomplished with less than ½ amp. This reduces power supply requirements for training aid applications, also simplifies the circuitry. Use of low power also obviates the need for a relay operating the circuit breaker simulator from a remote location.

This modification was made to simulate the action of an aircraft circuit-breaker, both mechanically and electrically.

In this case a training aid was needed to instruct maintenance personnel in the operation and trouble shooting of the P6M SeaMaster electrical system. The device was to simulate the power supply and distribution system of the airplane, and faithfully reproduce the effects undergone by the airplane when unusual conditions were introduced by the instructor.

The customary standard control for such a use is a magnetically-released, indicating push-button device which unlatches when the circuit is overloaded. To simulate this action, the coil of the manual control was rewound to operate by a current of only 0.3 amp, and two terminals were added. This new control is called the Klixon D6753-2 Circuit Breaker Simulator. From the face of the electrical panel it has exactly the same appearance as the MS25005 and MS25017 aircraft circuit-breakers. The coil terminals are wired into a switch circuit on the instructor's control panel, so that he may energize the coil and simulate tripping of the circuit breaker at will.

This control also accurately duplicates the trip-free characteristics of the MS25005 and MS 25017 circuit breakers. That is, the contacts cannot be held closed on an overload condition regardless of the position of the reset button.

The circuit breaker simulator has also been used to duplicate action of a cartridge fuse. In this case, the breaker is mounted behind an open-circuited fuse so that the cartridge holds the push button down. The line terminals of the circuit breaker are connected to the fuse terminals, and thus complete the circuit. When the coil is momentarily energized, the breaker is tripped and the circuit opened. Removing and reinstalling the fuse cartridge will operate the breaker push-button and re-close the circuit.

The training aid duplicating the electrical system of the SeaMaster is designed so that the instructor has on his control panel a number of multi-position rotary switches. Each switch can introduce a different type of malfunction of the system, and by turning a switch through its sequence of positions the effect of the malfunction on the system can be shown step by step. The final position of each switch causes a panel to light up on the display board in front of the students, indicating exactly what malfunction was introduced by the instructor.

By incorporating the Klixon D6753-2 Circuit Breaker Simulator, the Martin Company was able to use a power supply of 0.7 KVA, instead of the originally contemplated 2½ KVA.

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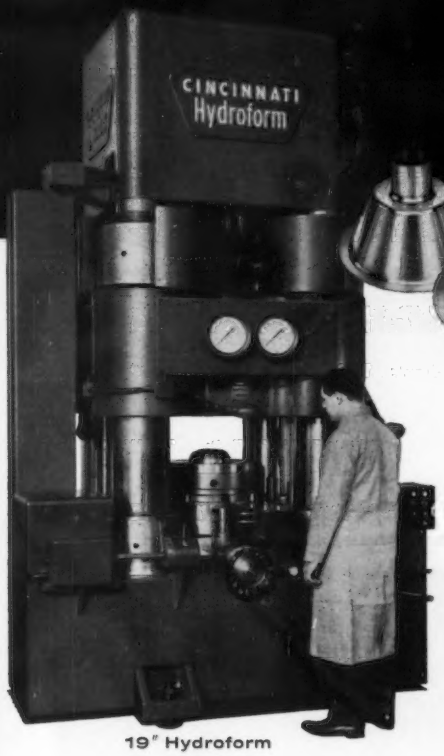

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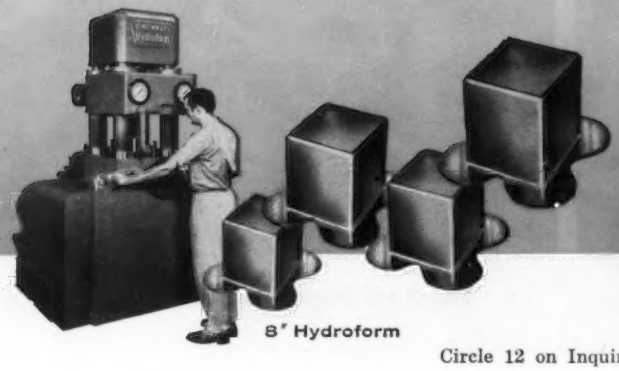
12″ Hydroform



8″ Hydroform

Hydroform

META-DYNAMICS DIVISION

Machines for Metal Forming and Heat Treating

THE CINCINNATI MILLING MACHINE CO.
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CINCINNATI

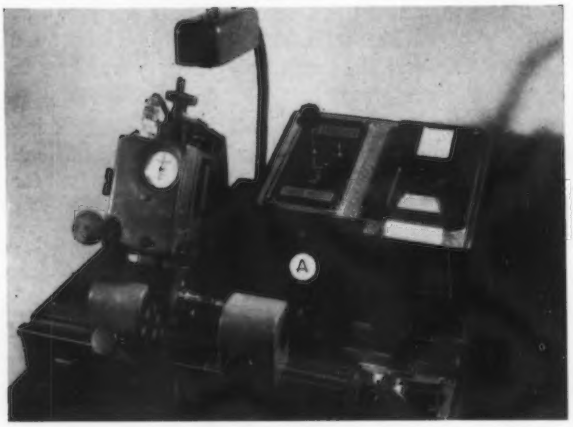
Circle 12 on Inquiry Card

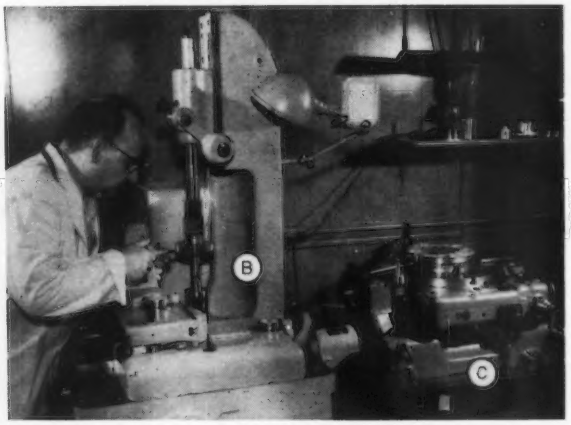
needed..."more gear" per dollar

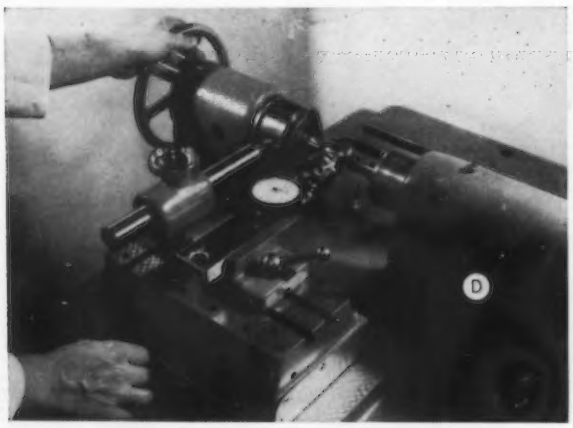
reliability demands may see new emphasis on AGMA precision Class-3 gears; sensitive gear-testers becoming essential

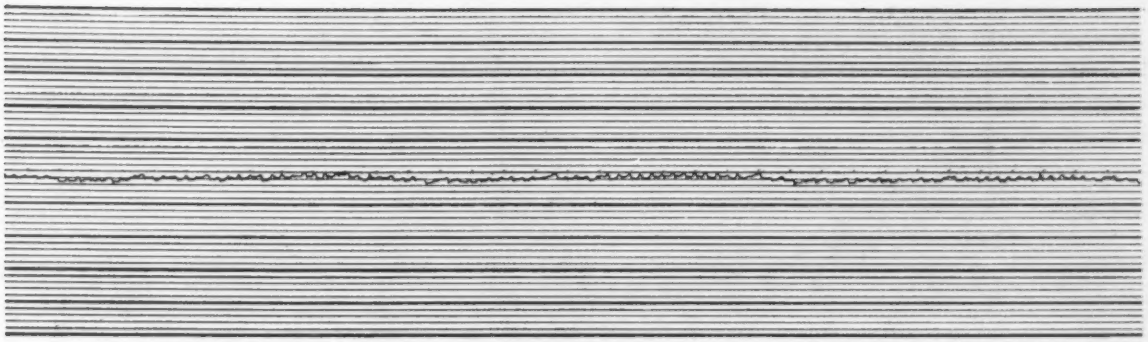
by S. Peter Kaprielyan

Equipment used by the gear-test lab of Eclipse-Pioneer includes the following machines: (A) Fellows No. 4 Red Liner used for two-flank roll checks; (B) Fellows involute checker; (C) Lindner rotary table for spacing check on 48 pitch and carrier; (D) National Broach and Machine Co. lead checker; (E) and the S & F two-flank roll tester for composite-error checking.









Are you getting the most from your gear cutting equipment?

Indications are that stricter demands for reliability, in missile parts and components, will soon be made. A House group recently noted that the services differ in their emphasis on reliability; it is now urging the Defense Secretary's office to survey these differences and upgrade reliability requirements. One outcome of this renewed stress on reliability may be a greater emphasis on AGMA Precision Class 3 gears.

continued on next page

SPUR GEAR DATA

BASIC SPECIFICATION	Number of Teeth	34
	Diametral Pitch	120
	Pressure Angle	20°
	Standard Pitch Diameter (N/P)	.2833
	Tooth Form—Standard Involute (AGMA 207) (unless otherwise specified)	———
	Max Calc. Cir. Thickness on Std. Pitch Circle	.01309
MANUFACTURING AND INSPECTION	Gear Testing Radius	.1416 $^{+.0000}_{-.0004}$
	AGMA Quality Class	Precision 3
	Max. Total Composite Error	.00025
	Max. Tooth to Tooth Composite Error	.0002
	Outside Diameter	.3000 $^{+.0000}_{-.0015}$
PROCESSING DATA	Measurement Over Two Pins (For setup purposes only. Finished gear must satisfy drawing specification when checked per note 2 below).	.3035 Pin Dia. .0144
	Testing Pressure (ounces)	2.9
	Max. Root Diameter (ref.)	.2593
	Top Hobbing Required unless Indicated	———

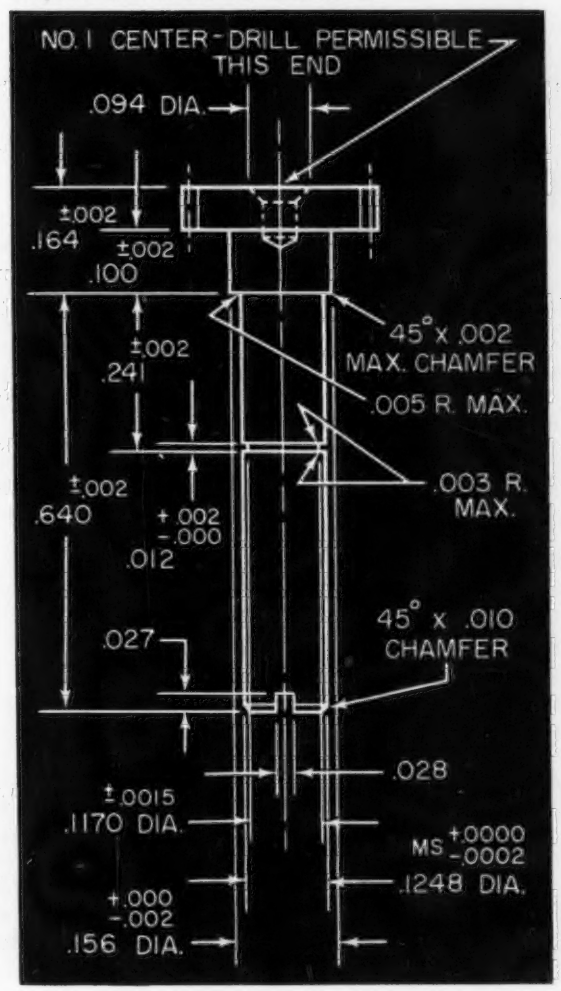
NOTES:—

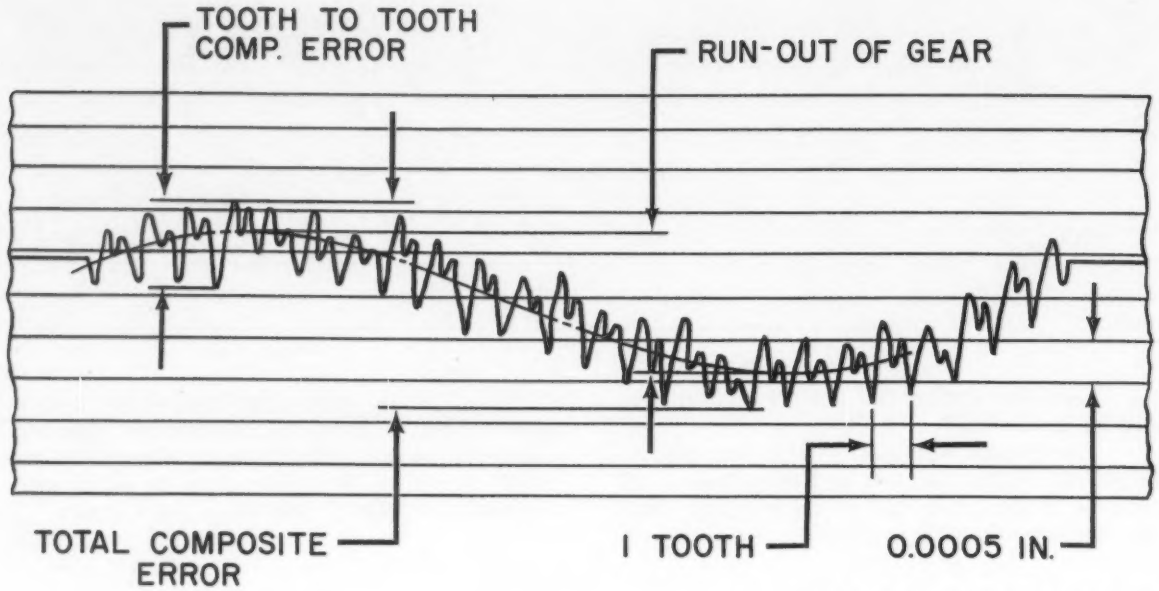
1—MS, designates the surface (or surfaces) on which this gear must be mounted for checking or generating.

2—This gear to be inspected per American Gear Manufacturers Association standard number AGMA 236. Except total composite errors must be within the testing radius limits.

3—Backlash at nominal center distance, including effect of total composite error must be .0000 to .0003 when checked with master gear.

This is a typical gear, produced at Eclipse-Pioneer, with its characteristic "signature" shown above. Maximum composite error in this case is 0.0002 in.





A two-flank Graphotest roll diagram is shown with an exaggerated graph to illustrate method of error interpretation.

"more gear"... continued

The painstaking and expensive nature of class 3 gear production has long been the bugbear of gear manufacturers. Nevertheless, the number of shops willing to live and cope with this situation has been increasing. The Eclipse-Pioneer division of Bendix Aviation Corp., makers of aircraft instruments, automatic flight-control equipment, and missile guidance components made this transition about five years ago.

Conventionally, extra care in sharpening of hobs, the stabilizing of gear blanks, and meticulous setup procedure have been known to pay great dividends in gear accuracy. Bendix however, went a step further in upgrading class 3 gear production by using extra-sensitive gear testing equipment. Among the recently-acquired equipment of this type, are included some 40 S & F gear testers with an instrument error of 0.000010 in. The result of these efforts was that while still using the same gear hobbers as before, and the same operators, rejection rates were reduced appreciably.

The testing procedure used for a typical class 3 gear takes place in three phases as follows:

(a) The operator of each gear hobber has access to an S & F two-flank roll tester, in this case, right next to his machine. As soon as he cuts the first gear of a series, he inspects it and makes corrections accordingly.

(b) The second phase of inspection takes place at the foreman's level, where every tenth gear is inspected.

(c) The gear-inspection lab performs the third phase by inspecting 100 per cent of the gears produced.

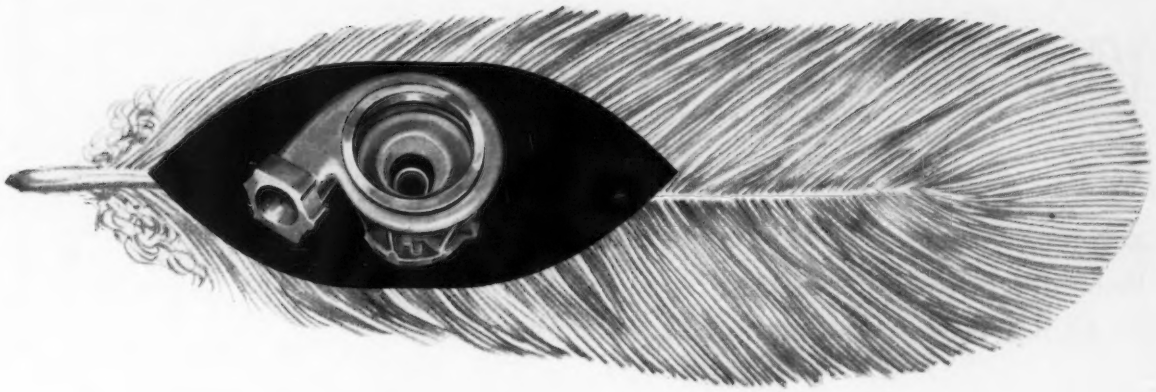
On coarse-pitch gears a two-flank roll test is made for composite error checking. The gears are brought into intimate contact, through spring pressure, and the variation in center distance is measured; errors are also checked separately in tooth spacing, lead, and profile. On fine-pitch gears, for the lack of individual error checking methods, reliance is made on composite checks.

A Graphotest recording indicator mounted on the S & F tester provides a permanent record in the form of a roll diagram for each gear.

◆

(Advertisement)

new weight saving material for missiles and high performance jet aircraft



NEW HIGH-STRENGTH . . . HIGH-PURITY ALUMINUM CASTING ALLOY

If you've been pushing A-356 to the limit of its physicals to scrape off every possible ounce of excess weight . . . then new alloy MA-356 was made to order for you. With a few minor changes in chemical composition, Rolle has produced what is essentially a new casting material. Highly responsive to heat treatment, it permits higher tensile strength, higher yield strength, and greater elongation. Rolle is pouring MA-356 now . . . in castings that consistently exceed the physical requirements of MIL-C-21180A. Check, for example, the typical sand cast range of properties MA-356 permits in the T-6 condition against what you can expect from conventional A-356 at left:

ALLOY (T-6)	U.T.S. (psi)	Y.S. (psi)	E (%)
A-356	40,000	30,000	3
MA-356			
minimum	40,000	30,000	5
maximum	50,000	40,000	2

One of the advantages of MA-356 is that any desired physical within the typical range can be emphasized through careful control of heat treatment of the casting. Even more exciting are the extremely high physicals that have been achieved with MA-356 in favorable casting configurations. Test castings have actually exceeded a tensile strength of 54,000 psi and yield strength of 44,000 psi with 2% elongation.

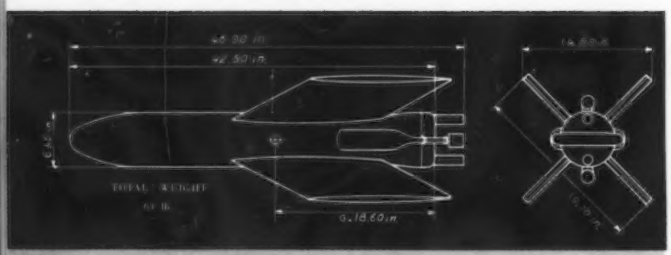
But no two castings are alike. It's impossible to predict the benefits MA-356 will confer on your sand and permanent mold castings without prints and specs. If you'd like more information on this new alloy, write for Technical Data Bulletin 1001. And when you do, why not ask for your copy of our 58-page light metals casting handbook . . . an engineering guide to aluminum and magnesium sand and permanent mold castings. Rolle Manufacturing Company, 317 Cannon Avenue, Lansdale, Pennsylvania, or call ULysses 5-1174.

ROLLE

SS-10 and SS-11 join Army arsenal

anti-tank missiles both wire controlled;
three different warheads may be used;
SS-11 has two-stages both solid propellant

by Ronald A. Cole



General configuration of the SS-11 is shown.

The SS-11 is shown on a stand. Note the side exhaust port for the booster rocket, the thin streamlined wing section together with sharp sweepback.

The U. S. Army recently announced the award of a $7.5-million contract to the French Government to produce the SS-10 and SS-11 anti-tank missiles. Initial quantities of these missiles will go to Seventh Army troops in Germany. Both are made by Nord Aviation of Paris, use solid propellant, and are reported as capable of destroying any tank in existence. The SS-10 is for infantry use whereas the SS-11 is for mechanized mobile units. So far 11 different countries have ordered these missiles in varying quantities.

Three Types of Warheads Used

To provide for flexibility of mission three types of warhead may be used. These are the hollow-charge type for armour piercing, the fragmentation type for anti-personnel use, and an inert type for practice firings. An armour-piercing head on the SS-10 and SS-11 will penetrate respectively 16.5 and 23.6 in. of steel.

Both missiles have cruciform wings rather than fins, and their flight paths are aerodynamic instead of ballistic. Mounting the wings at a slight angle to the body centerline gives rotation in flight.

Each wing consists of a thin steel skin wrapped around a balsa core and joined at the trailing edge. The wings are screwed to the main casing via root flanges. In the SS-10, the wings are slightly tapered with just a small amount of sweep on the leading edge. The wings of the SS-11 are sharply swept and have a streamlined symmetrical section of about seven per cent; a sharp leading-edge radius is used.

An SS-11 is being fired from an Alouette.

Here two SS-11 missiles can be seen mounted on an Alouette helicopter.

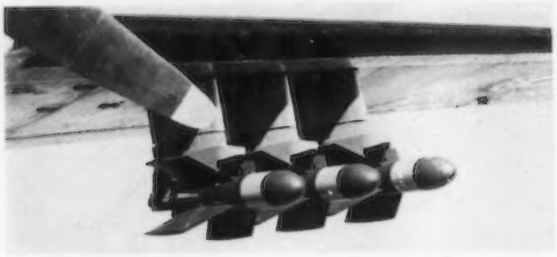
Approximate flight velocity is 620 fps for the SS-11 and 300 fps for the SS-10; however, their weight is considerable as compared with an anti-tank shell.

Wire-Control Used for Guidance

To both missiles, commands are transmitted through two fine wires trailing from bobbins mounted within the rear section of the missile body. The operator controls the flight path by a small stick while sighting through binoculars fixed on a pedestal at eye height. He steers the

An SS-10 missile is seen on its zero-length launcher. The toggle fastener seen is one of three which hold the warhead to the main body. Clearly seen are the slab-type wings and the streamlined blisters and slots through which the vibrating plates emerge.

SS-10 and SS-11 . . . continued



SS-11 missiles are shown mounted on an aircraft.

missile so as to eclipse his view of the target. A gyro provides a fixed plane of reference for all control actions as the missile rotates and pitches. This gyro is spun at 30,000 rpm and launched by gases from an explosive charge and coasts for the rest of the flight; at the end of a maximum-range shot this will have dropped by about 2000 rpm—not enough to affect control.

Two unusual methods of steering these missiles are used. At the root of each wing of the SS-10 there is a small streamlined blister slightly aft of the trailing edge. Each blister has a spanwise slot in its top and bottom surface. A small plate vibrates continuously so that it first appears through the top slot and then through the bottom slot. Control commands are electrically interpreted so that the rate of vibration is slowed down and the mode changed on individual wings. As a result, the plate stays exposed longer on one wing and provides a larger drag component.

In the SS-11 a variation of the same idea is used. Here four small plates are disposed around the main rocket exhaust tube. They continuously vibrate through slots so that they are alternately in and out of the exhaust flow. Control commands again modify the rate of vibration so that greater cut-off is experienced in any quadrant. This effects control by jet deflection. In both systems, as the missile rotates, first one plate and then the other controls the action in a particular plane; preference is provided by the gyro.

SS-10 Operable by Two-Man Team

Including an 11-lb warhead, weight of the SS-10 is 33 lb. The generator, control box and sight add to this weight but the complete system can still be handled by a two-man team. The warhead is carried separate from the main body which houses control gear, rocket motor, and spools of wire. Three toggle fasteners attach the head to the body prior to firing. A zero-length launcher is carried with the body.

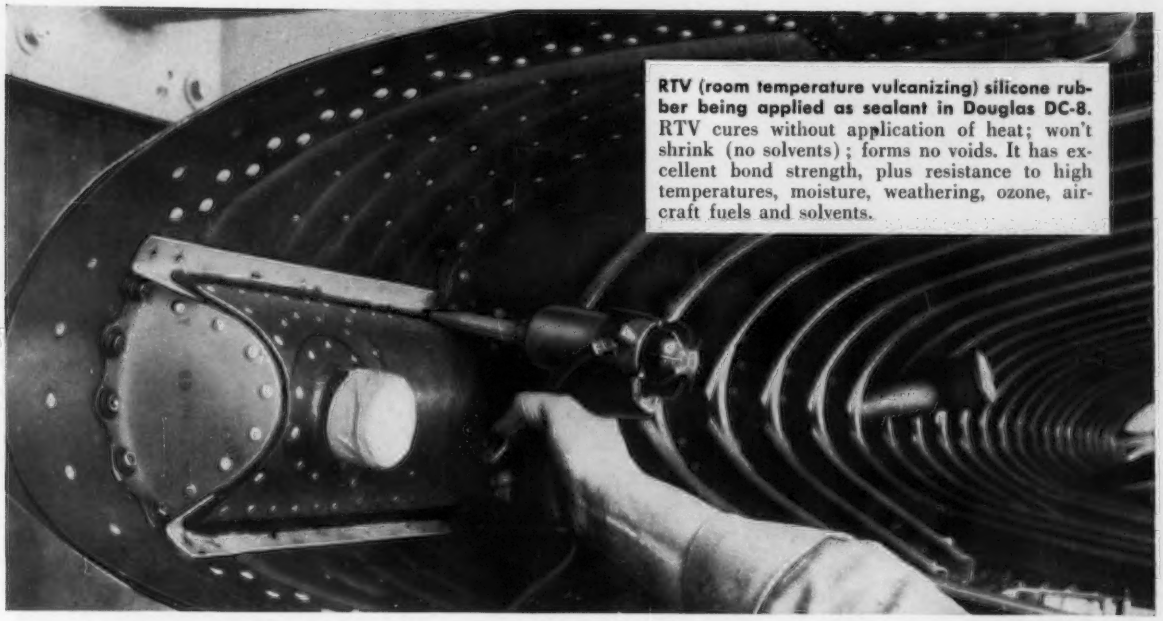
The rocket motor is divided into two parts. The initial or boost-phase motor is concentrically arranged around the main motor. The controller and generator operator are positioned about 300 ft away from the missile for safety. Their control over the missile is such that they can hit a target contained in a curved line trapezoid having a cone angle of about 60 deg. The nearest or base radius is at about 1600 ft from them, and the maximum radius at 4950 ft.

Basic weight of the SS-11, without launcher, is 63 lb and cannot be manhandled comfortably. For this reason it has to be carried on a transporter and treated somewhat like a piece of artillery. Like the SS-10 it can be carried on medium-performance aircraft at speeds up to 290 mph. It can also be filed from helicopters, jeeps, tanks, small trailers as well as from static emplacements. Apart from the greater weight, several pieces of auxiliary equipment are included which make it too complex to operate under infantry conditions.

The effective range of the SS-11 is up to 3830 yards, far greater than that of the SS-10, and its speed is over twice that of the SS-10. The solid propellant motor has two stages. The booster charge exhausts through two diagonal nozzles, one on either side of the body. This charge accelerates the missile to approximately 330 ft/sec in the first 1.4 sec of flight. During this time the sustainer is ignited and this progressively increases speed to about 620 fps at maximum range. Motor burning time is 22 sec; the propellant is of a type that does not deteriorate with good storage.

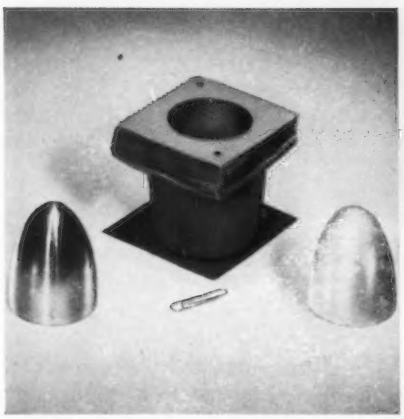
Operating range is between 550 and 3830 yards and again a 60 deg arc of control is provided. Minimum radius of turn is in the order of 1110 yards at the end of the first boost-stage, and it is possible to alter course 15 to 20 deg.

✦



RTV (room temperature vulcanizing) silicone rubber being applied as sealant in Douglas DC-8. RTV cures without application of heat; won't shrink (no solvents); forms no voids. It has excellent bond strength, plus resistance to high temperatures, moisture, weathering, ozone, aircraft fuels and solvents.

G-E RTV silicone rubber—a superior material for tooling, encapsulating and sealing



Prototype jet engine nose cone (right) cast in RTV mold. Epoxy parts cast in flexible RTV molds have a bright, glossy surface and reproduce extremely fine detail. No parting agent is required for even the most complex parts. High tensile and tear strength is retained even after prolonged heat aging.

Close-tolerance, non-standard helix gear cast complete in low-cost, one-piece RTV mold. Previously such replacement parts had to be machined by hand. Now they can be quickly and inexpensively replaced by using the broken part as a master.

Potting and encapsulating of electrical components, such as this aircraft transformer, are easy with RTV. It can be poured, sprayed, painted or applied by dipping. Temperature resistant from −60°F to +600°F; excellent resistance to high altitude arc-over and corona. Comes in wide viscosity range.

For application data and samples of General Electric RTV silicone rubber, write to General Electric Company, Silicone Products Department, Section BB72, Waterford, N. Y.

GENERAL ELECTRIC

Silicone Products Dept., Waterford, N. Y.

The relative size of the Vickers Vigilant and its portability are demonstrated by British "Tommy."

Launching of missile shown, putting a small knoll to advantage. The controller is held in one hand, using the thumb to actuate a small control column.

Britain's Vickers Vigilant

plastic fins, printed circuitry, and casing which permits parachute drop are features of 35 to 45 lb weapon pack

The Vickers Vigilant anti tank missile is a small, relatively light weapon, easily operable by the non-technical soldier under field conditions.

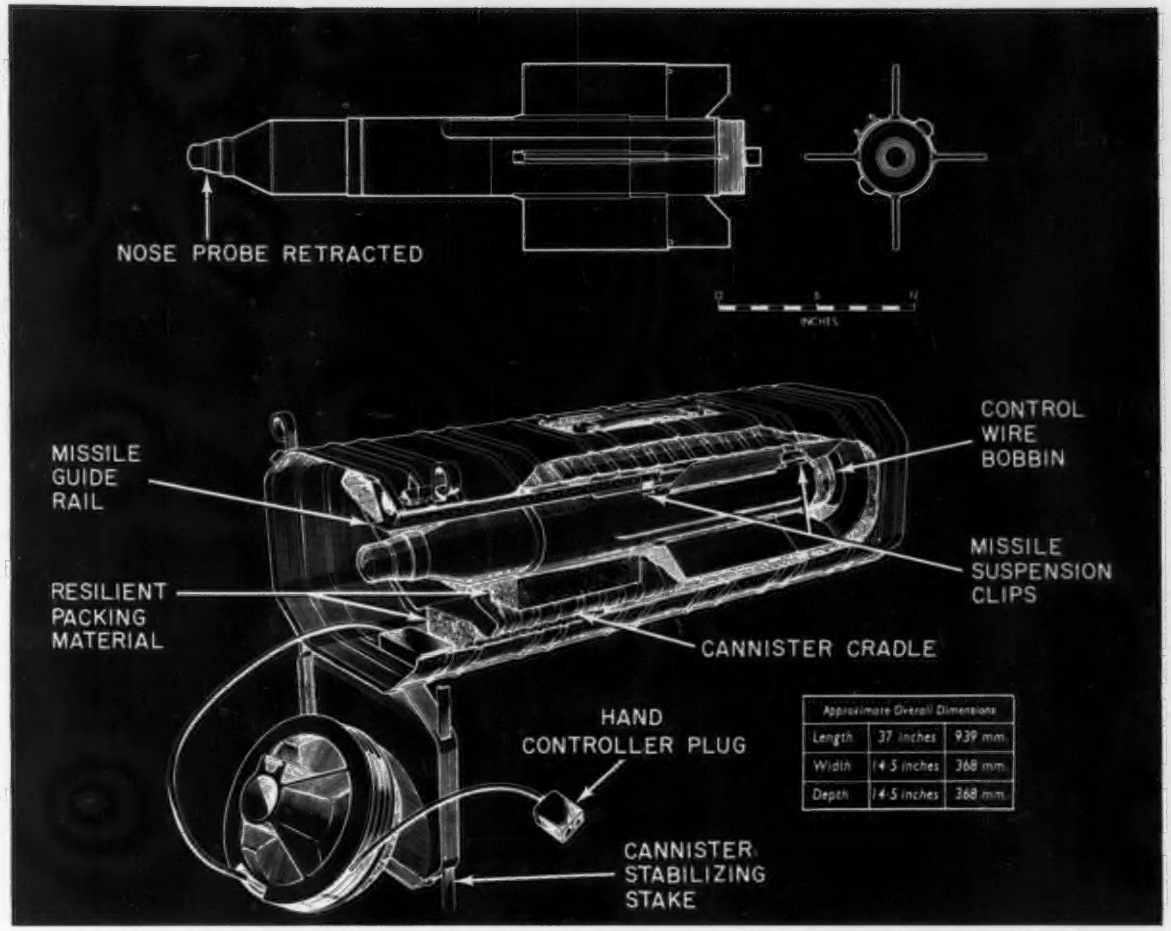
It is carried in a beaded, steel cannister which also serves as its launcher; extra packing material makes the cannister suitable for parachute dropping and normal rough handling. Varying degrees of shock protection are available, and depending on the amount of resilent packing, total weight may vary between 35 and 45 lb.

General Details

The cylindrical body has a conical nose which terminates with a detonation probe; protruding from this, there is a contact fuze which is extended to the required stand off distance when the missile is launched. The missile is carried, with the fuze retracted, to permit a shorter and lighter carrying case. The main body and the rocket-motor pressure-casing are of aluminum alloy. Two detachable fairings of reinforced molded-plastic run down either side of the main body. These allow interconnection between equipment at either end of the rocket motor. Printed circuits are used throughout, for reliability and ease of assembly.

Cruciform fins of about 13-in. chord are held in place by long "U" section spring clips. A thin plate-section is used for the fins with a round leading edge and tapered, hinged control surfaces at the rear. Fins consist of a reinforced plastic shell, filled with foamed plastic.

A bobbin around the rocket exhaust nozzle carries the thin, 2-core wire through which con-



General configuration of missile is shown. Cutaway sketch of canister reveals shock-proof cradling. Large nose-plug in canister front end rests detonator and serves as reel for controller cable.

trol commands are sent. The aft edge of control surfaces are notched near the body, to allow unwinding of the wire without fouling. An advantage of this wire link is that there are no practical counter-measures and electrical demands are small and can be met with small batteries.

Guidance

Guidance is via a small thumb-operated control column mounted on a hand grip. An insulated two-core cable connects the grip to the canister. The operator uses his control to continually bring the missile into his line of sight. For long-range operation it is possible to fit a pair of binoculars to the grip; to assist sighting at night or in poor visibility a small flare can be mounted on the missile.

Cannister

The cannister consists of an inner shell separated from the outer case by blocks of resilient packing material. Within the inner shell there is a rigid launching rail attached to the roof of the case. The missile hangs on this rail via lugs on the main body. At the end of the box there is a rubber closure which is removed before firing to let exhaust gases escape. The front lid hinges down to provide support at the launching angle of about 20 deg; two stakes located on the lid can be pushed into the ground to stabilize the cannister. Launching angle can be varied by adjusting the height of the cannister rear end.

ground-testing the ramjet

Marquardt equips 8-cell jet lab with "unusual" test facilities; turbojets used as heat source and exhaust device

By Philip Geddes

Ramjets are a breed unto themselves. They operate effectively from low subsonic to hypersonic velocities, at altitudes from sea level to more than 100,000 feet.

These high-speed air-breathing engines cannot be developed fully by calculation alone; it follows that their operating range must be simulated on the ground. For ramjets, this calls for unusual equipment.

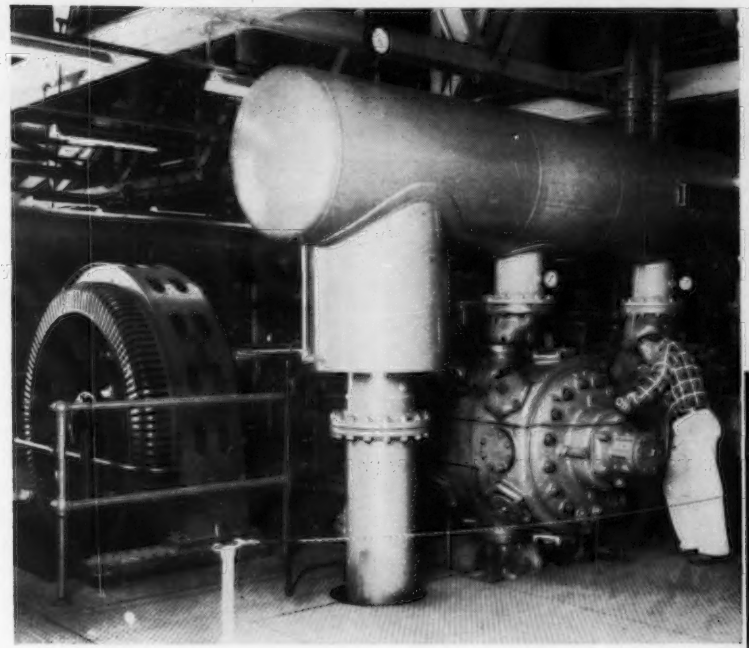
The Marquardt Aircraft Co., Van Nuys, Calif., operates a test laboratory for the U. S. Air Force in which complete ramjet altitude-simulation tests are performed. These facilities have saved valuable time and many millions of dollars that would have been spent in flight testing. Ample proof of thorough ground testing techniques is the performance of Marquardt's ramjet engines on the Bomarc. In 1958, not one Bomarc flight test was aborted due to failure of the two RJ-43 engines.

In the Marquardt Jet Lab, full-scale engine testing is conducted with air flows up to 800 lb/sec at pressures up to 200 psia and with stagnation temperatures up to 1200°F. Environmental testing for development of fuel controls, general variable geometry systems auxiliary power units, and components is performed in a series of functionally-independent test cells.

The complexity of the Jet Lab can be visualized best by studying one of the eight engine-test cells in operation.

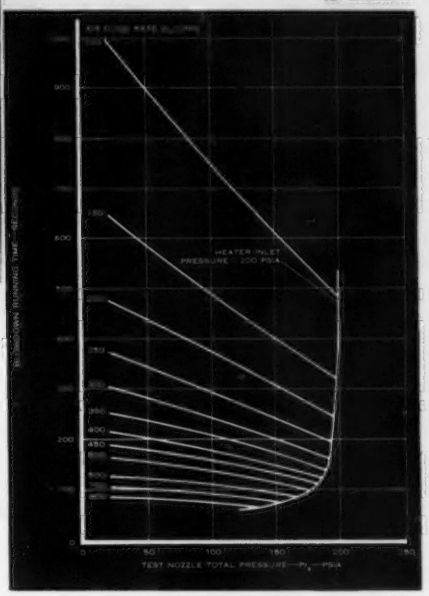
High-Altitude Test-Cell

Cell No. 8 is a high-altitude ramjet test chamber. Here, engines up to six feet in diameter producing 100,000 lb of thrust can be tested.



Electric-motor-driven reciprocating air-compressor (3 stage, 4250 HP) can fill blowdown storage tanks in 1¼ hr.

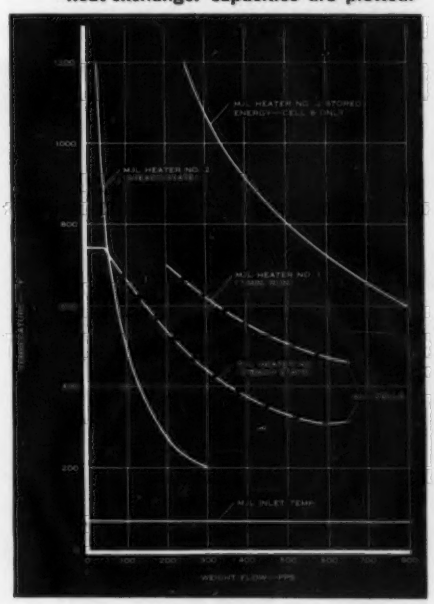
Cell No. 8 blowdown performance is shown.



Altitudes approaching the operational extremes of air-breathing powerplants are reproducible. Floor module sections permit two floor levels upon which a variety of ramjets or supersonic nozzles can be mounted.

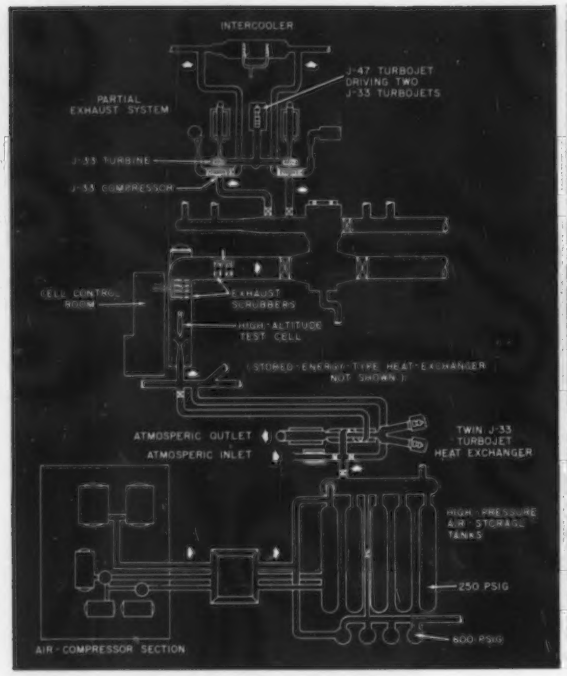
Test parameters and the engine are governed from a control room, less than six feet from the cell. The test item can be observed through viewing ports. Steady-state test information such as pressures, temperatures, fuel flows, is recorded on high-speed multichannel magnetic tape in binary digit form. Some 100 information channels are sampled 4 times per second. Transients to 700 cps are recorded using two 36-channel oscillographs, and to 80,000 cycles with Ampex tape recorders. When the particular test phase is over, the test data is played back and automatically punched on IBM summary cards. An IBM 704 computer is then used to correct for calibration errors and calculate the required parameters. This system reduces the time required to evaluate test results to about two hours.

Marquardt Jet Lab full-scale heat-exchanger capacities are plotted.

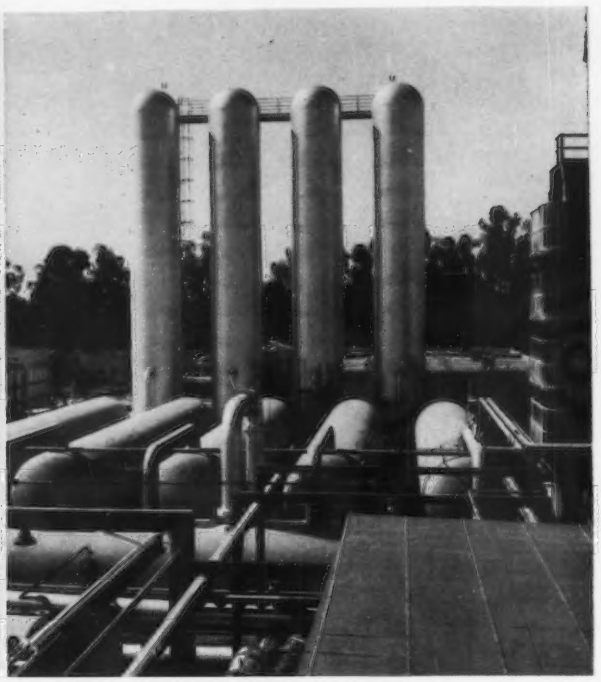


Blowdown Air Supply

The physical problem of displacing and heating large masses of air for tests is solved ingeniously in the Jet Lab. A total of 104,000 lb of air is stored in 10 cylindrical tanks: six at 250 psig and four at 600 psig with an isolation interconnect between the two sets of tanks. The tanks can be recharged in 1¼ hr with a 4250 hp compressor system. Blowdown air is ducted to the



Partial schematic diagram of ramjet test facilities illustrates high-pressure air storage and delivery system.

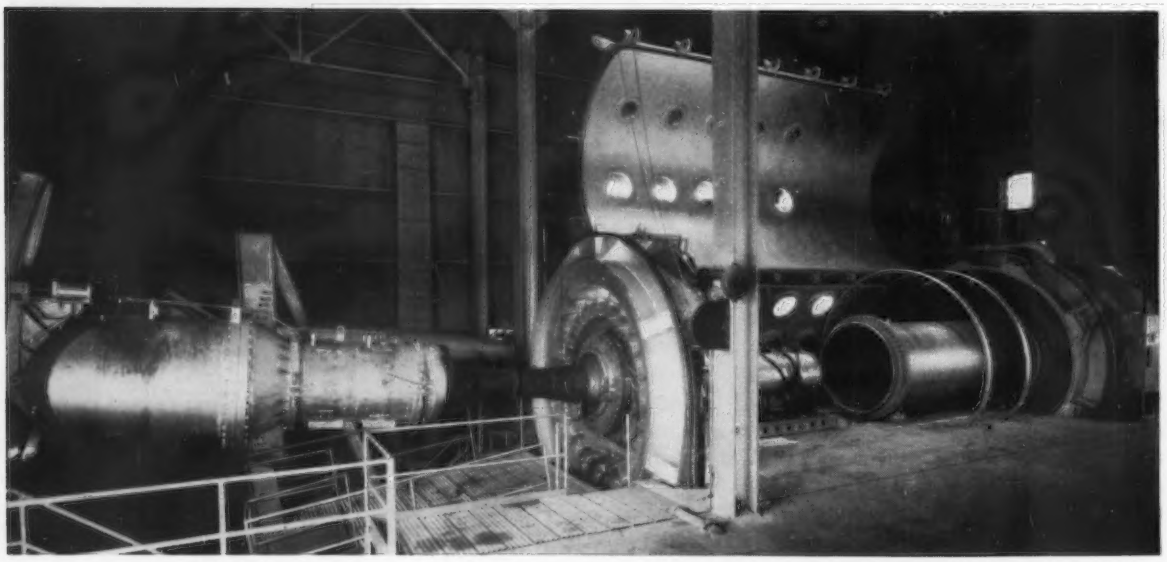


Six 250 psig (horizontal) air storage tanks and four 600 psig (vertical) tanks have a combined capacity of 104,000 lb.

ground-testing . . . continued

required cell past a series of lockout valves which insure high-pressure air only to the test cell being used. For most tests precalibrated free jet nozzles are used to simulate the Mach number around the engine inlet. Some tests are run with the engine inlet directly or indirectly connected to the air nozzle. The exact flow is required only on the in-

High-altitude test-cell No. 8 is 80 ft long. Articulated ducting at left, leading into cell, can be raised or lowered hydraulically to simulate airflow changes over engine inlet.



side of the engine; external drag data is determined from aerodynamic wind-tunnel tests.

Changes in angle of attack of the engine under test are simulated by moving the cell inlet nozzle relative to the engine, thus altering the direction of the airstream. The use of articulated ducting, hydraulically positioned, allows a range of +20 to −10 deg flow direction change at a rate of 10 deg/sec.

Stagnation Temperature

To simulate engine-inlet stagnation temperature for a specific Mach number, air is heated before the supersonic air nozzle by an unusual tube and sheet heat exchanger. The exhaust of two J-33 turbojet engines provides the heat required. Steady-state heat release is 100 million BTU/hr with a thirty second transfer rate of about 300 million BTU/hr. A second stored-energy type heat exchanger is available which uses chromized steel exchanger surfaces for high corrosion resistance. Its continuous capacity is 35 million BTU/hr with intermittent operation at 400 million BTU/hr. The basic heat-storage capacity allows all 52 tons of stored air, contained in the ten tanks, to be heated to 1200°F while flowing at 240 lb/sec.

Altitude Simulation

Using the two J-33's for a heat source is a startling enough application for turbojet engines, but in the exhaust system for cell No. 8 we find ten more J-33's. To evacuate the cell, the turbines of the J-33's are driven from the exhaust of five J-47 turbojets. Each J-47 is ducted to two J-33's and provides about 3000 shp for each of the two associated J-33 compressors. The ten J-33 compressors act as exhausters to draw air out of the cell. The exhausters can be ducted in parallel to produce a cell pressure of about 3 psia, or in series parallel giving a lower volume flow and cell pressures down to 1.3 psia or less. The use of turbojets for such a purpose may make their manufacturers perhaps blush, but the resulting system has proved adequate for continuous operation.

Exhaust-Heat Dissipation

The heat released by the ramjet under test is so great that the air flow into the exhausters must be cooled. A direct-contact exhaust-gas cooling system lowers temperature to a reasonable value. In this gas-scrubber system, cooling water at 11,000 gal/min is sprayed into the engine exhaust stream from a series of jets located behind the engine in the cell. The water is then carried to a 1½ million gal storage reservoir where it is cooled before recycling through the cell. Noxious by-products of combustion of special fuels are accumulated in the cooling water through the action of high-velocity venturi scrubbers in the cell. Low-velocity water eliminators downstream from the exhausters prevent fine droplets of contaminated water passing to atmosphere. The contaminated water is stored in the reservoir from which it can be circulated into the city sewage system over a long period of time.

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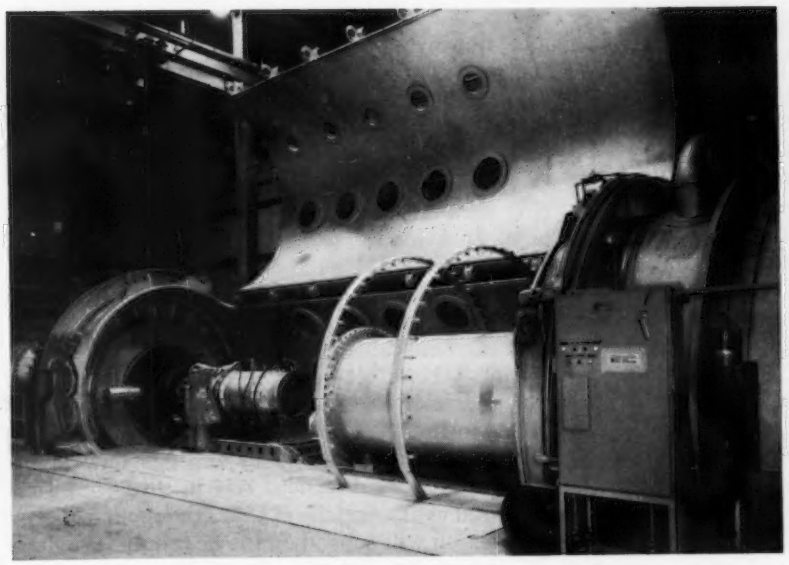
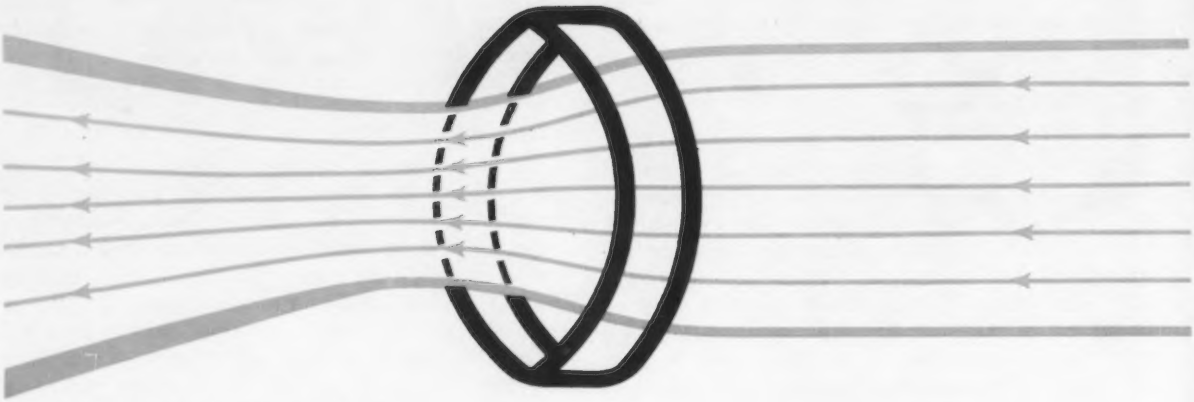


Huge clamshell door of 14-ft diam cell No. 8 is hydraulically operated. The two rings with protruding water jets are part of the exhaust gas scrubbing system.

what makes the Tu-104 so hot?



Soviet technical literature describes special exhaust nozzle; 18 to 22 per cent thrust increase claimed by "pinching exhaust with heat ring"

by Ronald A Cole

When the Soviet Tu 104 jet airliner first became known at the airports of Western capitals, the fact that such a large aircraft was powered by only two engines surprised all observers. An immediate search was started to explain the high thrust requisite of its powerplants to drive this aircraft which grosses in the region of 150,000 lb. All sorts of ideas and possible explanations were put forward, and finally the commentators compromised with themselves. They conceded that Soviet turbines were probably of high power, but suggested that this was due to the acceptance of bulky, rather large-diameter units. Furthermore, they were quick to say that performance at altitude was likely to be poor and range short on account of an inevitably-high specific consumption.

Further observations from reliable sources later underlined the fact that Russian gas turbines are in fact very powerful, and probably the most powerful in the world. Also, there have been insistent claims that these engines have specific fuel consumption at least as good, if not better than average. Thus, adoption of the large-diameter theory could explain the increased thrusts but it would not explain the good consumption figures. These two conflicting points have in the past led to considerable confusion and argument. As if to amplify the erroneous nature of our current thinking, the USSR set about a program of record breaking, using the Tu 104A. During 1957 this airplane claimed eleven international records, including those for speed over a closed circuit with payload, and a height record carrying more than 44,000 lb of payload.

The real reason for the excellent performance of Soviet turbojet engines has now become known. Most, if not all, of their performance edge has been attributed to the adoption of the "Vulis Nozzle"—a device which acts upon exhaust gases, and improves performance without increasing fuel consumption. The importance of this invention can be gaged from the fact that the resultant thrust increase is in the region of 18 to 22 per cent.

Basically, this special nozzle consists of a ring arrangement at or near the end of the jet pipe. It would appear to be flush or nearly flush with the internal surface of the pipe. Heat is added to the exhaust flow via this ring with the result that the flow is speeded up immediately behind it. This causes the flow to contract and then expand—the effect being the same as through a convergent-divergent nozzle. This pattern is maintained in the free atmosphere just aft of the ring. Thus, the kinetic energy of the gas flow is increased with a consequent rise in thrust. A fundamental characteristic is that the amount of flow contraction will depend on the heat input provided

by the ring. Just how the ring is heated is not known. It may be by air bled from the turbine stage or by separate burners. Whatever the method, it does appear that the system is lighter and less bulky than current afterburner attachments used on Western aircraft.

Basically then, the effect of the "Vulis Nozzle" is to add heat, and this is done by providing an optimum internal diameter for the particular flow conditions. Here the important parameters to be considered are the pressure ratio and temperature ratio across the ring; these decide the extent of contraction for a given flow-condition. Since flow through a jet engine varies with throttle setting, the amount of constriction will also depend upon that setting. At what point the ring is designed to give optimum conditions is not known. It appears likely, however, that in the case of civil transports the best cruising condition would be selected.

Study of the "Vulis Equation" shows that there is yet another important variable upon which thrust is dependent. This is the heat added from external sources, and one takes this to mean from ambient conditions. It appears possible that the internal diameter of the ring may be adjusted to allow for this feature. To avoid mechanical complexity, it seems possible that a general adjustment may be carried out on the ground. To insure optimum conditions in all phases of flight would mean that the rings would be adjustable in flight—a provision which is probably only resorted to in military applications. It is known for instance that Kuznetzov engines make use of a variable-outlet nozzle which works in conjunction with a variable "Vulis Nozzle." The two mechanisms are synchronized to operate in conjunction with each other as pressure and temperature ratios change.

The flow contracts at the ring, or perhaps just slightly before it and therefore leaves the walls of the tube. The loss of viscous effects here and the fact that the boosted gas-flow pattern is external to the engine pipe, means that there is not reduction of thrust due to drag losses. This most important feature is also taken care of in the "Vulis Equation."

The foundation of this device was laid by Vulis during WWII, a fact which in itself shows that Soviet engineers have been working on problems of reaction propulsion for at least as long as the rest of the world. Theoretical studies and investigations were made between 1941 and 43, and practical tests followed till 1945. Actual applications were seen during 1948, and at this time it is a basic feature of most, if not all, Soviet turbojet engines. It is believed to be in use on turboprop engines also. Presently, it is not thought that this principle is being utilized in rockets, although from the theoretical aspect it would seem a possible development.

Various reports and technical treatments of the theory of "Vulis Nozzles" have appeared, many of which have been available to the rest of the world, since the early 50's. Of these the journal "Technika Vozdushnogs Flota" numbers 3 and 4 of 1952 describe experiments carried out with the Tu 104 when fitted with the device. It should be mentioned that such nozzles are standard on Tu 104, 104A and 104B aircraft. Other reports have appeared in several issues of the journal "Grazhdanskaya Aviatsia" during 1957 and 58. There is also the designer's descripton in his own work "Termodinamika Gasovych Potokov" published in Moscow during 1950. Other mentions and treatment appear in "Daklady Akademii Nauk" volume 54 number 8 of 1946, and in "Prikladnaya Gasodynamika" by G. N. Abramovich published in Moscow during 1953.

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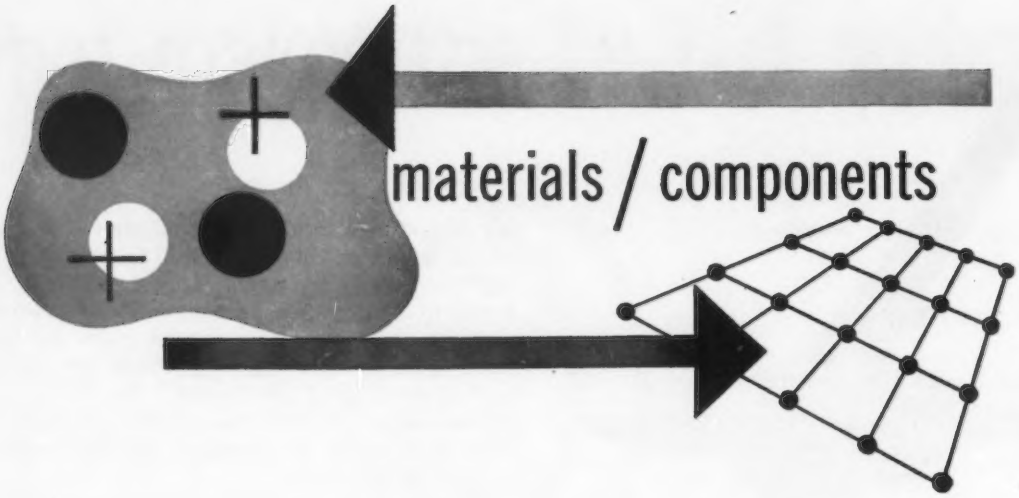


DIRECT-READING ALTIMETER

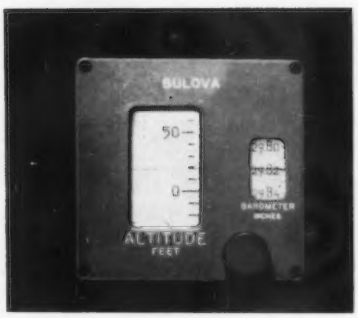
A new aircraft altimeter is said to cut reading time in half and virtually eliminate reading errors.

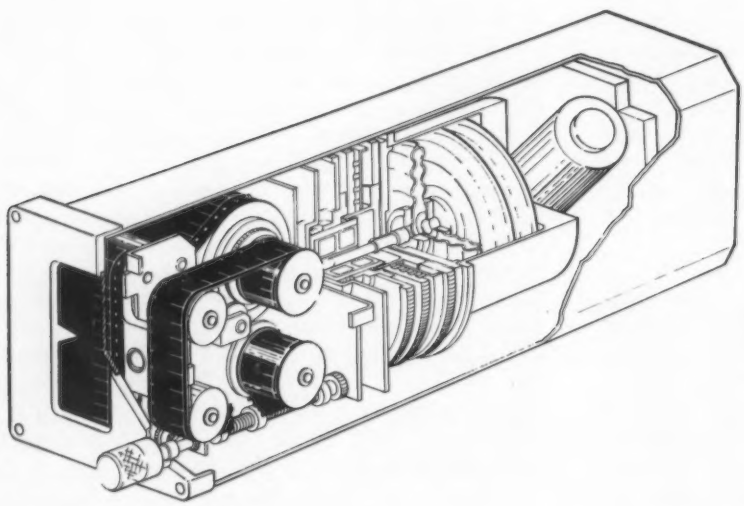
Tests showed a deviation of ±20 feet for new altimeter at 12,000 feet, against a 200-ft deviation for a conventional altimeter.

Readings are shown on a continuous logarithmic tape. The tape, about 40 ft long, ranges from minus 1000 to plus 65,000 ft, and is driven past a window in the instrument by a servo motor.

Output of the aneroid sensing elements is transferred to the indicating mechanism electrically. This frees the elements of all mechanical work, eliminating friction and producing a unique sensitivity.

Instrument is the product of a four-year altimetry project. Test quantity of 25 is undergoing extensive laboratory testing and flight evaluation in a wide variety of Air Force planes.





Cutaway shows (l to r) altimeter windows, knob for setting barometric pressure, 40 ft long tape, servo motor and acceleration compensating mechanism, three aneroid pressure capsules, pilot tube connection.

Static error is less than 10 ft at sea level, less than 50 ft at 40,000 ft. Altimeter is 3¼ in. square, 8½ in. long, weighs 4.9 lb. Tape's gradations range from 50 ft per inch at sea level to 500 ft per inch at 60,000 ft.

Bulova Watch Co.

Circle 50 on postcard for more data

INFRARED DOME TRANSMITS TO 12 MICRONS

The largest infrared dome manufactured in one piece (12 in. diam) has been delivered to NADC, Johnsville, Pa.

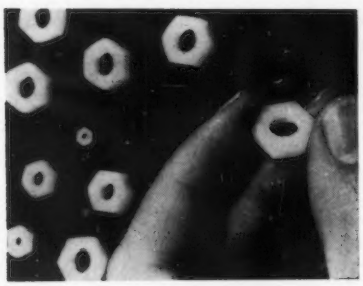
The arsenic - trisulfide hemisphere will be used to make comparative ground and airborne studies of the detection capabilities of infrared equipment using various infrared detectors.

Transmitting out to 12 microns it will cover the near, through the far, infrared regions. The unit is made of Servofrax glass.

Servo Corp. of America

Circle 55 on postcard for more data

NEW SIZES FOR NYLON HEX NUTS



Ten sizes of molded nylon hex nuts have recently been added to the availability list. Sizes range from a tiny No. 2 through a 5/16-in. screw diam.

The nuts have a washer face and are double countersunk. They are made with a single chamfer and are standard thickness (except for the 5/16-in. sizes which are jam nuts) with unified series Class 2B threads.

Gries Reproducer Corp.

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four-count 'em-four

Helipot builds four distinct lines of precision components. And each offers the most in design, production, delivery and value.

1 **Beckman Rotating Components**
Unique size 8's . . .
plus 11's, 15's and 18's . . .
in servomotors, rate generators, inertia and velocity damps, gearheads and black box assemblies.
Acceleration and response?
Like heaven on earth!

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3 **Beckman Standard Breadboard Parts**
24-hour delivery . . .
1,139 items . . . myriads of precision gears, grid plates, hangers, shaft hardware, limit stops, dials, differentials, magnetic clutches, ball-and-disc integrators . . . but everything!

4 **Helipot Precision Potentiometers**
When it comes to pots, we do make the most! A full single-turn family: 15 series in 1/2" to 3" dia.
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19 series in 7/8" to 3-5/16" dia.
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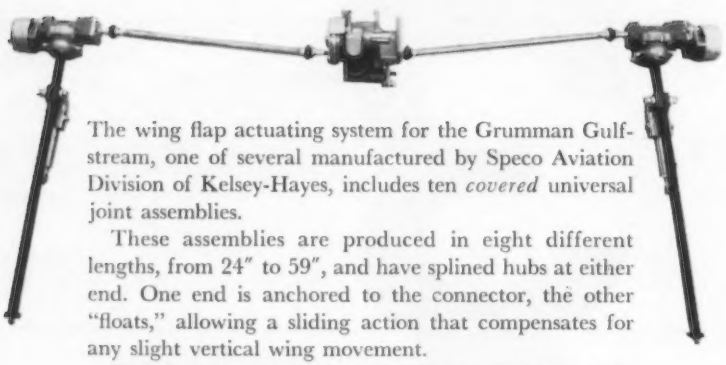
10 APEX covered UNIVERSAL JOINT assemblies help the Grumman Gulfstream flex its wings!



The wing flap actuating system for the Grumman Gulfstream, one of several manufactured by Speco Aviation Division of Kelsey-Hayes, includes ten *covered* universal joint assemblies.

These assemblies are produced in eight different lengths, from 24" to 59", and have splined hubs at either end. One end is anchored to the connector, the other "floats," allowing a sliding action that compensates for any slight vertical wing movement.

Sealed, lubricant-retaining covers, an exclusive Apex feature, insure continued, trouble-free operation of the actuating system. Apex manufactures a complete line of aircraft universal joints, standard and special, that meets or exceeds all requirements of Spec. MIL-J-6193A, Class 1 and Class 2, as indicated on QPL-6193-2.

SEE OUR CATALOG IN SWEET'S

or write, on your company letterhead please, for Catalog 28 and Universal Joint Data Sheets.

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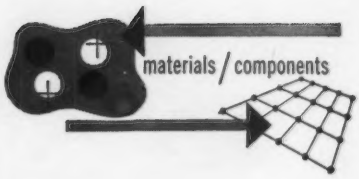
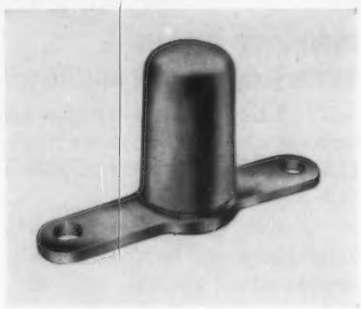


ANCHOR NUT



Fifty to seventy five per cent weight reduction is claimed for lightweight two lug dome anchor nut. Now made of alloy for added durability, nut is available in 1-32 and ¼-28 thread sizes. It is used for holding tanks and for pressure—sealed areas.

Nutt-Shel Co.

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PROTECTIVE COATING IS WATER SOLUBLE

Removable, scratch-resistant coating for temporary protection of the aluminum, magnesium, and stainless steel is applied by spray or roller. Air dries in five minutes to 80B Rockwell hardness, yet is easily removed by warm water rinse. Coating allows essential markings on metal to show through.

Industrial Metal Protectives Inc.

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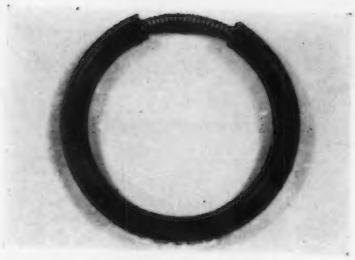
AIRCRAFT AND MISSILES MANUFACTURING

provides engineers with valuable "how-to" information on design and production aspects of the nation's most dynamic industry.



O-RING SEALS ELIMINATE NEED OF ANTI-EXTRUSION DEVICES

Hydraulic O-rings seal shows promise of eliminating need for anti-extrusion devices at high temperatures. Seal uses a spring insert which is concentric with the O-ring.

Particular application is in a nuclear environment where the use of Teflon back-ups is not suitable. Other applications include hydraulic seals above 400°F.

Performance consistent with the following conditions is hoped for:

- Temperature —65 to 600°F
- Pressure 0 to 4000 psi
- Cycling 35 cpm, variable stroke from 1 to 5 in.

Chance Vought Aircraft Research

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ELECTRONICS COOLING ACHIEVED BY SMALL FAN

Miniaturization and efficiency are claimed for a vane-axial motor-driven fan developed for cooling electronic equipment.

Impeller has less than 2 in. diam; yet, the unit provides a flow of 46 cfm under 2½ in water pressure and 37 watts input. 75 cfm free flow is possible in a 400 cycle 3-phase version.

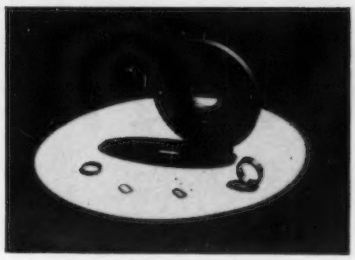
It is also available with a single phase, 400 cycle motor; or in single-phase and 3-phase high-slip motor versions designed for improved operational characteristics at high altitude.

Garrett Corp.

Circle 56 on postcard for more data

FERRITES FOR MAGNETS ARE MACHINABLE

Highly permeable, highly machinable MN-30 ferrite is intended for use in magnetic cores. It is suitable for applications at frequencies up to 500 kc. Eddy current losses are minimized by its resistivity. Virtually all sizes and shapes can be obtained with dimensional tolerances of



±0.001 in. Density ranges from 4.9 to 5.0 gm/cc.

Kearfott Co.

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23 CELL BATTERY FOR MISSILE TELEMETRY

Battery for missile telemetry has eighteen 15 amp-hr High-Rate silver-zinc cells and five 10 amp-hr High-Rate silver-zinc cells. Normal discharge

voltages are 27.0 v and 6.6 v.

Weight is 26 lb, dimensions are 6.75 in. high by 10.187 in. diam. It has been constructed to operate 200 miles beyond Earth at temperatures ranging from 125°F to 0°F. Unit has a shelf life of one year, and a rechargeability of ten cycles.

Called Silvercel, battery is pressurized and comes in a case of corrosion-resistant magnesium alloy.

Yardney Electric Corp.

Circle 52 on postcard for more data

STRUCTURAL "CERAMIC" USABLE ABOVE 5000°F

New material, Avcoite, is a reinforced ceramic that resists gas erosion at 5000°F.

Material can be fabricated as rocket nozzle or nozzle components. Negligible changes in rocket nozzle throats have resulted at temperatures of 5000°F after 60 sec firings. Excessive stresses cause material to deform rather than fracture.

Avco Research & Advanced Development Div.

Circle 53 on postcard for more data

SILICON CARBIDE FOAM

Silicon carbide foam, a new lightweight corrosion-resistant material giving thermal insulation up to 4000°F, is now in pilot plant production.

Suggested applications are in nuclear reactors, furnace insulation, missiles, rockets, and aircraft.

Easily machined with standard steel cutting tools, it can be fabricated into complex shapes at close tolerances.

A cubic foot weighs only 16 to 18 lb. The high density form weighs from 30 to 35 lb/cu ft. Physical strength varies between the low and high density forms with the latter capable of supporting loads of about 800 psi. Thermal conductivity is about 5 BTU/in/ft²/hr/°F at 800°F for the low density foam.

The Carborundum Co.

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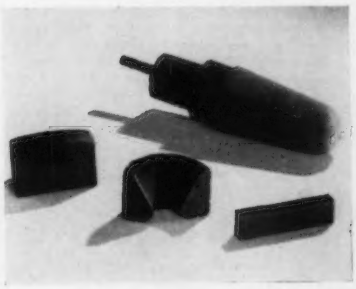

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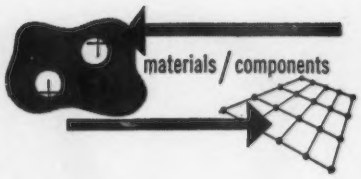

NEW TYPE MOLECULE

A new type of molecule may lead to the development of plastics stable to 750°C.

The new compounds are based on boron and phosphorous and are known chemically as phosphinoborines.

The newly - synthesized molecule is a "linear chain of repeating, tetracoordinate phosphinoborine units" with a molecular weight of about 12,500.

Two basic types of phosphinoborine materials have been developed. One is a translucent, milky white compound that is heat-resistant but is brittle. The other has an appearance much like existing plastics but does not possess heat stable characteristics.

American Potash & Chemical Corp.
Circle 61 on postcard for more data

GAS TURBINE BELIEVED WORLD'S SMALLEST

Called the Turbo-Mite, a miniature gas turbine engine, is available in 5 and 10 hp models. Weight is just 30 lbs. It is 13½

in. long and 10 in. in diameter.

The Turbo-Mite can be used as an auxiliary electrical power unit, portable generator drive, portable pumping system, or as a portable pneumatic system source.

Curtiss-Wright Corp.
Santa Barbara Div.
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AIRCRAFT & MISSILES MANUFACTURING DIGEST OF RECENTLY PUBLISHED TECHNICAL MATERIAL

DESIGN

X-15 . . . THE WORLD'S FASTEST AND HIGHEST-FLYING AEROPLANE. *Flight* (May 8, 1959) 5 pp. Background, basic design features and mission discussed. Cutaway sketch of principal features is included.

DESIGN APPROACH TO THE ALLISON MODEL 250 ENGINE. R. S. Hall. *SAE paper #49 R* (April 3, 1959) 26 pp. Development program, design considerations and performance characteristics are presented for a 250-hp gas turbine.

FIRST AIRBORNE ATOMIC ENGINES WILL BE NUCLEAR-CHEMICAL HYBRIDS. G. N. Nesterenko, A. I. Sobolev, Yu N. Sushkov. *Space/Aero.* (April, 1959) 3 pp. Third article of a series based on a Soviet engineering report covers major design considerations.

RAMJETS. *Astro.* (April, 1959) 13 pp. Group of five articles discusses various aspects of ramjet engines as follows: A future for hypersonic ramjets, G. L. Dugger; Ramjet trends, E. Perchonok; Ramjet fuel-air control, L. Muhlfelder; Ramjet combustion, R. Breitweser; Supersonic ramjet diffuser design, R. B. Pearce, Jr.

ANTI-ICING FOR THE GAS TURBINE HELICOPTER ENGINE. T. A. Dickey, O. Dumler, and J. R. Untied. *SAE paper #49S* (April 3, 1959) 28 pp. Design considerations, thermal characteristics, development experiences, and final results of the development of a system for the T53—a free turbine shaft power gas turbine in the 860 to 1000-hp class.

PRODUCTION

BLADES FOR SIKORSKY HELICOPTERS. E. Altholz. *Mach.* (May 1959) 8 pp. Materials, tooling, inspection, and balancing phases of helicopter blade production are presented.

HANDLEY PAGE VICTOR. *Acft. Prod.* (May, 1959) 6 pp. Structural features and production methods are briefly described. Spotwelding is used in primary structure; corrugated-core sandwich panels are used extensively in wings and tail surfaces.

STRETCH FORMER COMPENSATES FOR YIELD STRENGTH VARIATIONS. *Iron Age.* (April 23, 1959) 2 pp. A 50-ton capacity Cyril Bath stretch-forming machine, being installed at Convair, can form 360 deg ring in one pull.

FLUOROSCOPY PROVES FAST METHOD IN CHECKING HONEYCOMB PANELS. W. R. Bear and W. S. Diehl. *Iron Age.* (May 7, 1959) 3 pp. How Convair (Fort Worth) uses fluoroscopy to inspect brazed stainless-steel sandwich panels used in the V-58.

ZERO POINT ONE. A. M. Dexter. ASTE *paper #195*, 11 pp. A look at our standards of length measurements; how they have come about, and how they are being modified for the needs of tomorrow.

MATERIALS AND PROCESSES

OPTIMUM TOLERANCES OF SHEET MATERIALS FOR FLIGHT VEHICLES. G. A. Hoffman. *Western Av.* (May, 1959) 4 pp. Current sheet-stock tolerances for beryllium, titanium, aluminum, and steel evaluated from the designer's viewpoint.

BREAKTHROUGH IN TUNGSTEN FABRICATION. D. E. Perry. *Missiles and Rockets.* (March 23, 1958) 2 pp. Deep drawing and spinning research at Fansteel Metallurgical Corp. opens new applications for missile electronics, propulsion and structures.

EPOXY BONDING OF AIRCRAFT STRUCTURES. H. S. Kraus. *Adhesives Age.* (April, 1959) 5 pp. Semi-automated adhesive bonding system speeds the production line at North American Aviation.

HOW TO GET THE MOST FROM SHEET METAL IN HIGH-TEMPERATURE SERVICE. H. A. Pearl. *Materials in Des. Eng* (May 1959) 5 pp. How existing sheet

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. . . 10 times as fast with precision OSBORN Brushamatic® Methods

JET ENGINE COMPONENTS *are precision finished automatically at high production rates on Osborn Brushamatic® 51-OOL Machine.*

HERE'S how a jet engine manufacturer has broken a production bottleneck . . . saved dollars and days in the precision-finishing of jet engine components . . . with Osborn Brushamatic® Methods.

Sharp edges, burrs or scratches on components cause stress concentrations and resulting fractures—so a high degree of surface refinement is essential. *Tedious hand finishing each of these parts used to take 80 minutes.* Still, job quality was inconsistent . . . costly in time and money.

Today, Osborn Brushamatic does the same job in 8 minutes . . . 10 times as fast . . . with a high-quality, uniform finish held to microinch specifications.

It's typical of how Osborn Power Brushing works to help *you* speed production . . . cut costs . . . improve product quality. Write for details. *The Osborn Manufacturing Company, Dept. AM-6, Cleveland 14, Ohio.*

Osborn Brushes

BRUSHING MACHINES • BRUSHING METHODS
INDUSTRIAL BRUSHES • FOUNDRY PRODUCTION MACHINERY

materials can best be used for reusable manned and unmanned vehicles that have to withstand outer skin temperatures of 2000°F for 1 to 100 hr in an oxidative environment.

GOVERNMENT RELEASES

A STUDY OF REFRACTORY MATERIALS FOR SEAL AND BEARING APPLICATIONS IN AIRCRAFT ACCESSORY UNITS AND ROCKET MOTORS. L. B. Sibley and others. A 59-page report evaluates commercially-available ceramics and cermets for rubbing-wear behavior under conditions applicable to aircraft accessories. Friction, wear, and corrosion behavior were studies in an oxidizing atmosphere from 1000 to 1800°F. Static corrosion-resistance of several materials was determined in a nitric acid oxidizer used in some rocket-propellant pumps. (Order PG 151483 from OTS, U. S. Department of Commerce, Washington 25, D. C.; price $1.50.)

THE MECHANICAL PROPERTIES OF CERTAIN AIRCRAFT STRUCTURAL METALS AT VERY LOW TEMPERATURES. R. L. McGee, J. E. Campbell, R. L. Carlson, and G. K. Manning. A 63-page report gives results obtained with 17-7PH and AM-350 stainless steels; AISI 4340 and Tricent steels, 7079 - T6 aluminum and ZK60A-T5 magnesium alloys, and A110AT, C110M, and 6A1-4V titanium alloys at —253°C (Order PB 151459 from OTS, U. S. Department of Commerce, Washington 25, D. C., price: $1.75)

AN INVESTIGATION OF THE RELATIONSHIP BETWEEN MICROSTRUCTURE AND CREEP-RUPTURE PROPERTIES OF HEAT-RESISTANT ALLOYS. A. P. Coldren and J. W. Freeman. A 71-page progress report discusses the influence of hot-working on alloy properties at high temperatures. Conditions of working can be used to control microstructural variations in a manner, which cannot be obtained in any other way, to develop structures superior in properties to any other treatment, according to the report. (Order PB 151421 from OTS, U. S. Department of Commerce, Washington 25, D. C.; price: $2.)

BOOKS RECEIVED

A SIMPLIFIED TECHNIQUE OF CONTROL SYSTEM ENGINEERING. G. K. Tucker and D. M. Wills. *Minneapolis-Honeywell Regulator Co.*, 1958. 303 pp. $5.00. This book offers a practical approach to those interested in process control. No mathematical control-theory has been included, except for a few basic formulas and graphs used to explain fundamental dynamic analysis—"dynamic" implying that conditions are changing during the analysis. It explains how a control system works as a signal-transmitting system; what transient-response conditions define stable performance; how to use frequency-response data to choose and adjust a controller, to find ways of improving control, etc.

DYNAMICS OF FLIGHT; STABILITY AND CONTROL. B. Etkin. *Wiley*, 1959. 519 pp. $15.00. This book is intended for senior and graduate students with a knowledge of mathematics (including complex numbers and differential equations), basic mechanics, and aerodynamics. Fundamental aspects, applications and some "typical" results are treated. The author has provided the basic tools for an understanding of the dynamics of flight, in the hope that these shall allow inquiry in "new directions." Chapter headings include the following: static stability and control; general equations of unsteady motion; the stability derivatives; stability of uncontrolled motion (longitudinal, lateral); mathematical aids; response of the airplane to actuation of the controls; flight in turbulent air; inverse problems; automatic stability and control; specialization to missiles; machine computation and simulation.

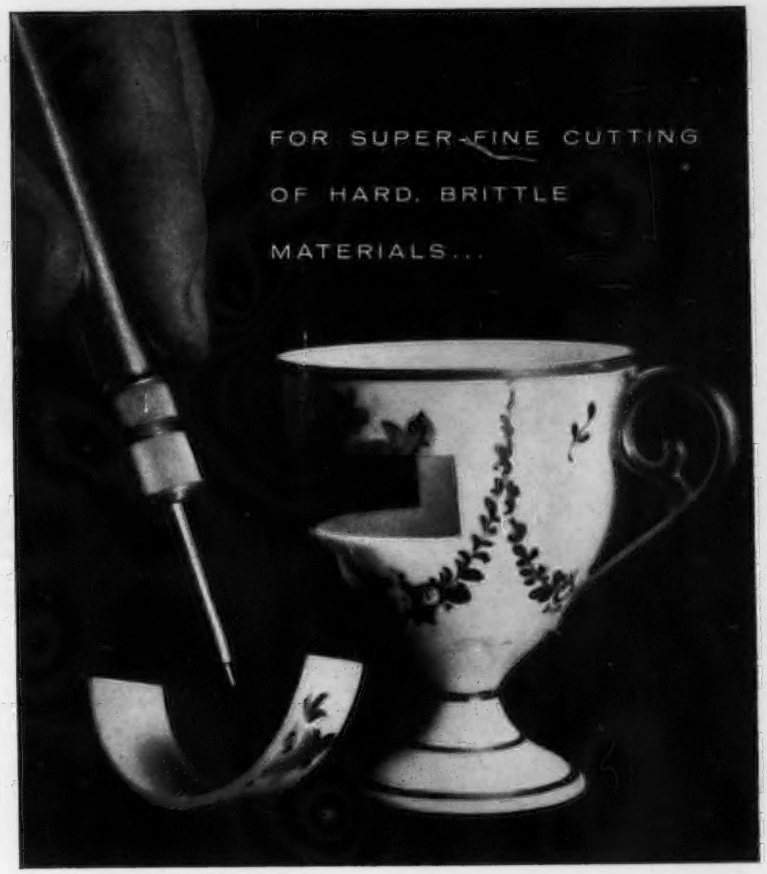
REVIEWED IN THIS ISSUE

Periodicals and Papers

Acft. Prod. Aircraft Production (British)
Adhesives Age. Adhesives Age
ASTE paper. American Society of Tool Engineers paper
Astro. Astronautics
Flight. Flight (British)
Iron Age. The Iron Age
Mach. Machinery
Materials in Des. Eng. Materials in Design Engineering
Missiles and Rockets. Missiles and Rockets
OTS. Office of Technical Services
SAE paper. Society of Automotive Engineers paper
Space/Aero. Space Aeronautics
Western Av. Western Aviation

BOOKS RECEIVED

A Simplified Technique of Control System Engineering. Minneapolis Honeywell Regulator Co.
Dynamics of Flight: Stability and Control. Wiley



THE S. S. White Industrial Airbrasive Unit

We don't recommend slicing up the family's fine Limoge China, but this does illustrate the precisely controlled cutting action of the S. S. White Airbrasive Unit. Note how clean the edge is, and how the delicate ceramic decoration is unharmed.

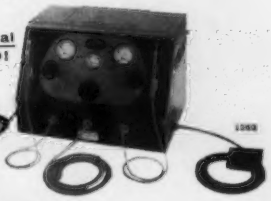
The secret of the Airbrasive is an accurate stream of non-toxic abrasive, gas-propelled through a small, easy-to-use nozzle. The result is a completely *cool* and *shockless* cutting or abrading of even the most fragile hard materials.

Airbrasive has amazing flexibility of operation in the lab or on an automated production line. Use the same tool to frost a large area *or* to make a cut as fine as .008"!...printed circuits...shaping and drilling of germanium and other crystals...deburring fine needles...cleaning off oxide coatings...wire-stripping potentiometers...engraving glass, minerals, ceramics. Jobs that were previously thought impossible are now being done.

Send us samples and specs on your difficult jobs and let us test them for you.

SEND FOR BULLETIN 5705A... complete information.

New dual Model D!



S. S. White Industrial Division
Dept. 18A, 10 East 40th Street, New York 16, N. Y.
Western Office: 1839 West Pico Boulevard, Los Angeles 6, California

MISSILE STAGE-SEPARATION SIMULATOR

Test stand has been developed for ground testing the release mechanism used in separating missile stages.

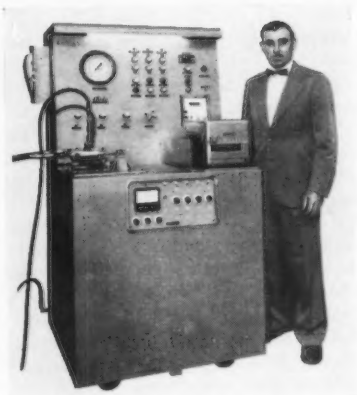
The stand meets the demand for a stable stand, recording permanently in milliseconds. It simulates actual pressure inside and outside the missile.

Dry nitrogen gas is used as non-explosive, non-toxic means for developing correct pressures. In action sequence, gas activates correct high-pressure solenoid. Timer can be set from one microsecond in conjunction with high-pressure gage which maintains tolerance of less than one per cent in pressure.

Engineers decided a medium was needed to simulate the pressure encountered in separating the missile. They utilized a round metal disc of about ½ in. diam. Pressure needed to puncture this disc is same needed for operation of release mechanism.

The Hicks Corp.

Circle 74 on postcard for more data



MEASURES AND SORTS NONMAGNETIC METALS

Portable eddy current instrument accurately measures electrical conductivity.

Testing jobs include determination of hardness, alloy, and heat treat condition; sorting mixed nonmagnetic metals; checking tensile strength of aluminum; investigating fire damage to aircraft.

FM-110 induces eddy currents within the test piece by means of a ½ in. diam. handheld probe. These currents affect the impedance of the probe coil as a function of the conductivity of the material. With the probe on one side of the test piece, the large knob is turned to zero; the meter and conductivity is read on the left-hand scale.

Compact instrument weighs only 4½ lb. Total range is 8 per cent to 107 per cent I.A.C.S., with an accuracy better that ±3 per cent of scale reading, and usually better than ±1

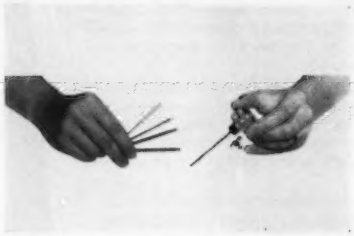
per cent when used on a comparative basis.

Three volts from two standard flashlight batteries power the self-contained unit.

Magnaflux Corp.

Circle 69 on postcard for more data

TORQUE WRENCH



Flexible torque wrench is designed to provide positive torque control ranging from 5 to 18 lb when tightening small hex socket screws.

Tool is out-fitted with quickly interchangeable blades and wrenches to handle a wide range of tightening problems.

Hermann Engineering & Sales Co.

Circle 76 on postcard for more data

MASS ASSEMBLY OF RETAINING RINGS

Automatic, hopper-fed unit is designed for high-speed assembly of external type retaining rings.

Each machine is specifically designed for customer's mass production needs. Usual practice is to furnish the basic ring-dispensing components. Customer then constructs his own assembly station from schematic blueprints also provided.

Waldes Kohinoor Inc.

Circle 64 on postcard for more data

ROLL FILE

Roll File units keep up to thirty-six rolled blueprints, charts, drawings, or tracings neat, clean, in order. For bulky materials, a nine-tube file is also available.

Only fifteen inches square, file protects valuable drawings against dust, fibre and water damage with heavy-gauge steel casings and dust-proof doors. Units bolt together for easy stacking to any height. Fingertip convenience is provided by standing Staktubes on end near the drafting table.

Stacor Equipment Co.

Circle 72 on postcard for more data

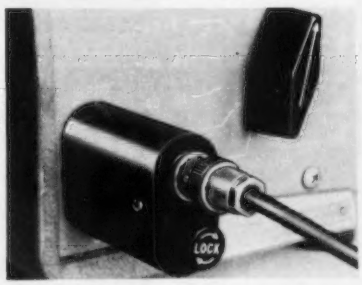
ALUMINUM SCAFFOLDS

Aluminum scaffolds on wheels are assembled from one-piece folding sections stacked to desired height and bridged by span platforms. Stairways inside the lightweight scaffolds provide easy access to work levels.

Up-Right Scaffolds

Circle 73 on postcard for more data

LOCKING ADAPTER



A new locking adapter provides greater reliability in laboratory and production tests. Makeshift jacks and connectors causing erratic contact ruin many measurements. The adapter locks on standard binding posts on ¾ inch centers, provides convenience and reliability of coaxial connectors.

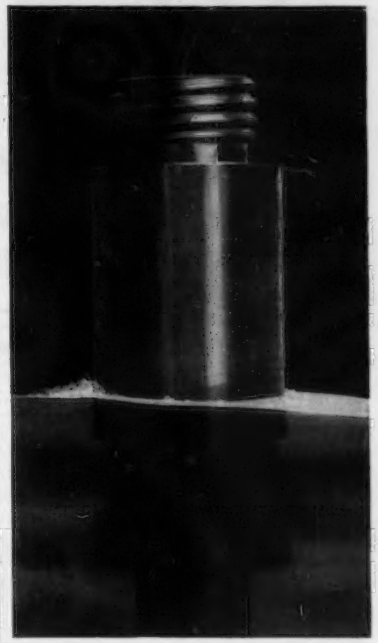
Highland Electric Co.

Circle 63 on postcard for more data

"PHANTOM BLUE" REPRODUCTIONS

Transparentized vellum produces a direct positive blueline reproduction which cannot be reproduced. This can be used as a working master for selective re-drawing when pencil or

MEASURE FUEL LEVEL WITH MICROMETER ACCURACY!



ACOUSTICA ULTRASONIC continuous gauges and liquid level switches are unequaled for the measurement and control of LOX, kerosene, nitric acid and exotic fuel. Accurate up to 1/64 inch... unaffected by liquid variables... operate instantaneously... consume infinitesimal power... no spark or radiation hazard. Now integrated in major military propellant utilization and liquid control systems. Expert Acoustica engineers can help you with your gauging problems. Send for further information.

NEW YORK
LOS ANGELES

acoustica
ULTRASONIC GAUGING SYSTEMS

Acoustica Associates, Inc.
Dept. AMM, Fairchild Court, Plainview, N. Y.

Send information on:
☐ Continuous gauges ☐ Liquid level switches

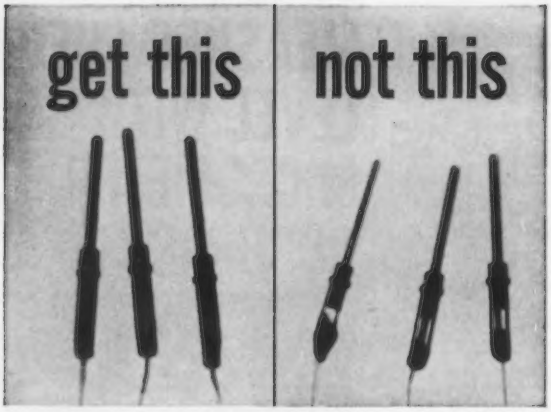
Name_____

Company_____

Address_____

City_____ Zone____ State_____

Circle 20 on Inquiry Card



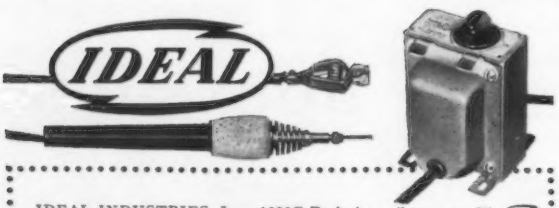
Actual X-ray Photos Show How IDEAL Thermo-Tip Resistance Soldering Tools Reduce Costly Voids in Winchester and Cannon Plug Pins

Because the whole pin is heated, "cold-flow joints" are eliminated; failures are greatly reduced

	Conduction Method		Resistance Method	
Pin No.	Length of void	% of void	Length of void	% of void
1	0.12″	40	0.00″	0
2	0.12″	40	0.00″	0
3	0.07″	23	0.05″	17
4	0.18″	60	0.00″	0
5	0.06″	20	0.06″	20
6	0.05″	17	0.04″	13
7	0.02″	7	0.05″	17
8	0.08″	27	0.01″	3
9	0.09″	30	0.07″	23
10	0.12″	40	0.09″	30
11	0.15″	50	0.04″	13
12	0.12″	40	0.06″	20
13	0.09″	30	0.01″	3
14	0.12″	40	0.08″	27
15	0.11″	37	0.02″	7
16	0.10″	33	0.04″	13
17	0.07″	23	0.04″	13
18	0.09″	30	0.09″	30
19	0.11″	37	0.10″	33
20	0.11″	37	0.06″	20
21	0.05″	17	0.01″	3
22	0.15″	50	0.00″	0
23	0.11″	37	0.05″	17
24			0.07″	23

● These production test results from a major Aircraft manufacturer prove the superiority of Ideal Resistance Soldering Tools to the best available commercial soldering irons. Voids averaged 33% with soldering irons. With resistance soldering only 14%.

In addition, higher production speeds were possible on Cannon plugs and operators were less subject to painful burns. Send for descriptive literature.



IDEAL INDUSTRIES, Inc., 1390G Park Ave., Sycamore, Ill. IDEAL

Gentlemen: Please send complete catalog information about Ideal's Thermo-Tip Resistance Soldering Tools.

Name_____

Company_____

Address_____

City_____ Zone____ State_____

Circle 27 on Inquiry Card

* If It's New, It's No Doubt Mystik

NEW! 7000-G TAPE for

Extreme Temperature Range —110° to +550° F.

MYSTIK BRAND FIBERGLAS TAPE

with Silicone Adhesives

A new concept in pressure-sensitive tapes—an essentially inorganic pressure-sensitive tape accepted by the aircraft, electrical and electronics industry.

7000-G has a tightly woven, high-tensile Fiberglas® backing with a pressure-sensitive silicone adhesive. Superior thermal and electrical properties make it ideal for many applications previously not possible for pressure-sensitive tape.

(Conforms to Government Specification MIL-1-19166. Approved as Class H Insulation.)

Write for full information on Mystik Brand 7000-G and the complete Mystik line of high and low temperature tapes using silicones with Mylar®, aluminum, copper, and Teflon.

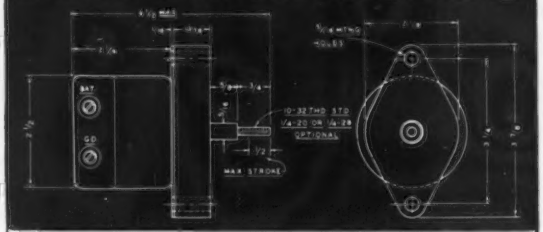
Mystik Adhesive Products, Inc.
2635 North Kildare Ave.
Chicago 39, Illinois

MYSTIK BRAND TAPES SELF-STIK

PACKAGING • PROTECTIVE COVERING • PRINTABLE • ELECTRICAL TAPES

Circle 28 on Inquiry Card

D.C. SOLENOIDS



Synchro-Start **SS SERIES SOLENOIDS** are for operating engine throttles, fuel pump racks, chokes, etc. and are available with several variations.

VOLTAGES (D.C. Only)
6V. 12V. 24V. 32V.

CURRENT DRAW (Pulling)
50A. 30A. 17A. 7.5A.

CURRENT DRAW (Holding)
1.7A. .95A. .28A. .25A.

DUTY
Continuous

CYCLES
Not to exceed 6 per minute

PULL
Approximately 10 lbs. over ½" stroke

WEIGHT
2¼ pounds

SYNCHRO-START PRODUCTS, INC.
8151 N. RIDGEWAY AVENUE · SKOKIE, ILL.

Circle 29 on Inquiry Card

ink lines are added.

Called Phantom Blue Transparent 206PBT, vellum is useful in engineering departments to permit printing confidential marginal information to accompany an original drawing.

206PBT may be penciled or inked in for running one or more Chromtex color overlays. A separate PBT print is prepared as a master for each color.

Frederick Post Co.

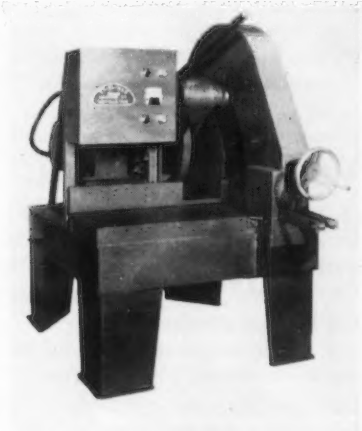
Circle 71 on postcard for more data

HIGH POWER CHOP-SAW

New-design suspension system and drive method boosts the power of this chop-saw to 30 hp.

Chop-or-swing type, high-speed saw can be used with a grinding wheel. It has wide application in the aircraft and missiles field for both production and maintenance work.

Special features include



sealed-bearing spindle, timing belt drive, dynamic suspension system permitting fingertip feed

Ty-Sa-Man Machine Co.

Circle 65 on postcard for more data

SERVOMECHANISM KIT

Kit of precision parts is designed to construct Model 20-200 subminiature servo mechanisms for use in laboratory, prototype or limited production applications. Conceived for versatile assembly to airborne, military and commercial requirements, the inertias and friction of the associated gearing are low enough to be compatible with size 8 or 10 components for which the equipment is designed.

Servo Development Corp.

Circle 67 on postcard for more data

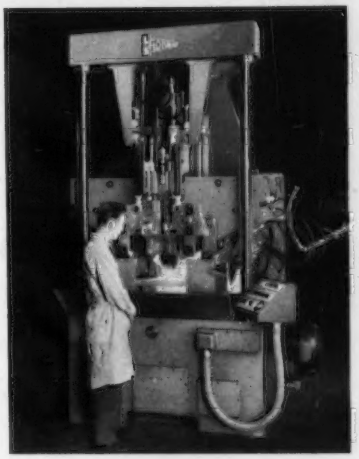
PROCESS PRODUCES SHELL-TYPE FORMS

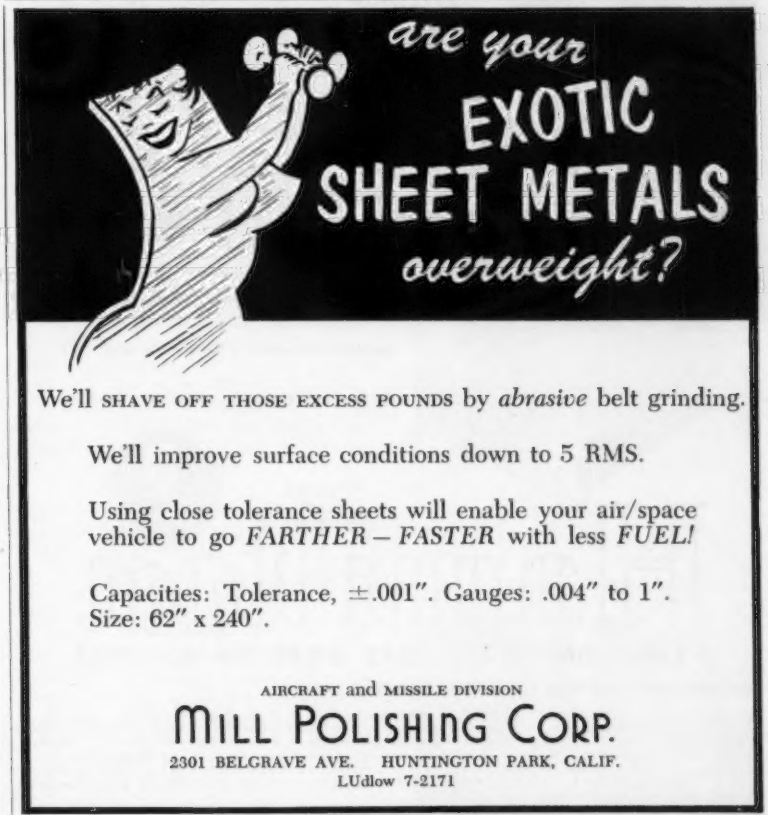
Tall, shell-type cylindrical parts similar to those produced by deep-drawn techniques may be economically formed by the "Flo-Reforming" process.

Process utilizes a vertical Floturn machine plus one or more press reforming operations with Reform tools.

Floturn Div.
Lodge & Shipley Co.

Circle 66 on postcard for more data




are your
EXOTIC
SHEET METALS
overweight?
We'll SHAVE OFF THOSE EXCESS POUNDS by *abrasive* belt grinding.
We'll improve surface conditions down to 5 RMS.
Using close tolerance sheets will enable your air/space vehicle to go *FARTHER – FASTER* with less *FUEL!*
Capacities: Tolerance, ±.001". Gauges: .004" to 1". Size: 62" x 240".
AIRCRAFT and MISSILE DIVISION
MILL POLISHING CORP.
2301 BELGRAVE AVE. HUNTINGTON PARK, CALIF.
LUdlow 7-2171

Circle 21 on Inquiry Card

POWER THREADER

Hand-fed power threader for tapping holes, cutting external threads, and other common drill press operations in metal or plastics, is being introduced.

The Sensi-Threader performs a variety of operations such as hand threading and tapping; precision under-sizing of threads to be electroplated; chamfering, deburring, countersinking, stud-threading, reaming and spot facing, and shaving plating build-up on plating hooks.

All work is hand fed, which enables the operator to feel strain, such as when tapping holes, and ease off the feed rate to prevent breakage of the tap.

Because of this "sensitiveness," the use of this machine on experimental runs, short runs, or on delicate threading and tapping jobs eliminates most tap breakage, loss of operator time, and parts rejection.

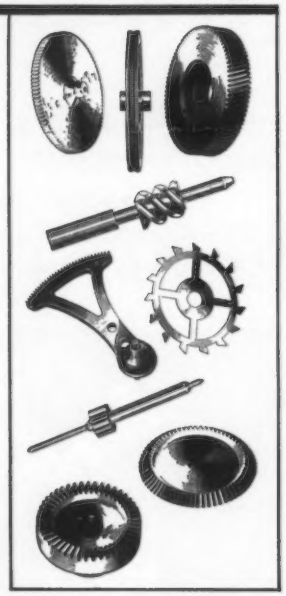
Sensi-Threader Sales Co.

Circle 70 on postcard for more data

-GEARS

. . . to critical tolerances

2461



Aircraft and Missile men • • • • your precision gear problems can be solved • • simply • • by application of the Hamilton **PRECISION** Gear Hobbing Machine

• • • an **AMERICAN** machine • • • • designed and built especially for work like yours. Write • • • now • • • for our free literature packet No. GH 840.

Hamilton

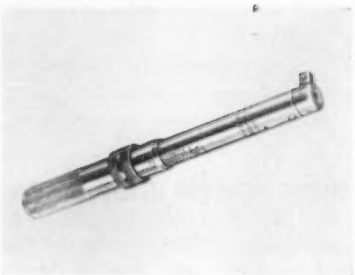
PRECISION SMALL-GEAR HOBBING MACHINE

THESE ARE REPRESENTATIVE USERS OF HAMILTON GEAR HOBBING EQUIPMENT

AiResearch Manufacturing Co. • Duncan Electric Co. • Bendix Aviation Corp. • Victor Adding Machine Co. • Lear, Co. Minneapolis-Honeywell Regulator Co. • Geophysical Machine Works • Hughes Aircraft Co. • Westinghouse Electric Corp. • Rockwell Meters, Inc. • Borg Products Division • Herschede Hall Clock Co. • U. S. Navy Electronics Laboratory • Redstone Arsenal • Smallwood & Son Machine Co. • Link Aviation, Inc. • Bell Aircraft • General Mills • Elgin National Watch Co. • U. S. Naval Gun Factory • Grimes Manufacturing Co. • Texas Instruments, Inc. • McDonnell Aircraft Co. • American Machine & Metals • Stromberg-Carlson Co. • Hamilton Standard • U. S. Gauge Co. • Western Gear Works • Schlumberger Well Surveying Corp. • Douglas Aircraft.

THE HAMILTON TOOL COMPANY • 882 SOUTH NINTH STREET • HAMILTON, OHIO

MICROMETER-TYPE TORQUE TOOL



Tool tells operator when pre-set torque has been reached. Clicking at the desired torque, it eliminates glancing at dials and scales. After release, it automatically resets itself.

Single tool measures torque in both left and right direction without adapters. It is ideal for close quarter tightening.

Apco Mossberg Co.

Circle 75 on postcard for more data

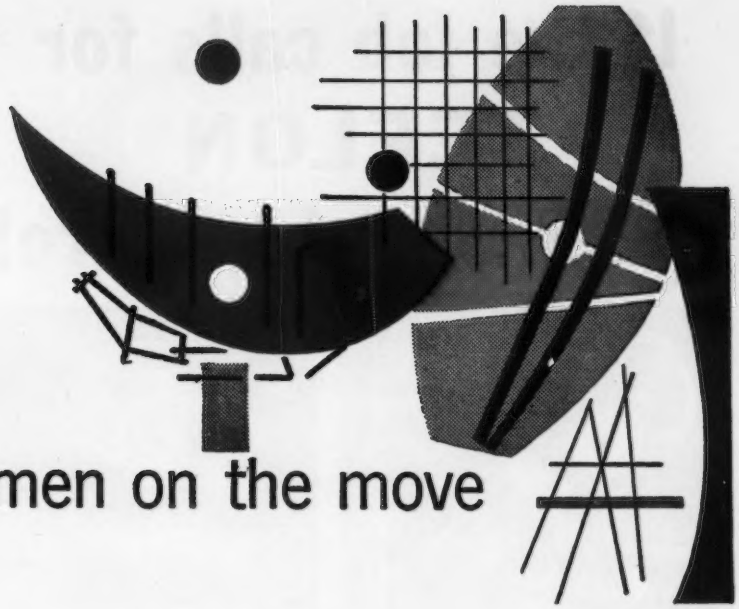
MACHINABILITY MANUAL

"Machinability Manual No. 1" was written as useful tool for those concerned with the removal of metal on turning and boring operations.

Major components of the manual: two vinylite plastic dial type instruments. Selector on left gives average speeds and feeds for conditions of setup rigidity. Dial rotates to a key setting for material.

John A. Hedrick

Circle 68 on postcard for more data



men on the move

ROBERT W. MEALS, assistant manager of Allegany Ballistics Laboratory Company is being assigned special duties in the Chemical Propulsion Div., Hercules Powder Co.

CONRAD KUNZE, appointed assistant to the executive vice president of Convair Div. WILBUR E. EMISH succeeds Kunze as manager of industrial engineering at Fort Worth.

DR. JAMES T. GREY, appointed director of the research planning staff, rocket divisions, Thiokol Chemical Corp.

KARL H. GUTTMAN has joined Astrodyne, Inc. as an Engineering Design Specialist. H. R. RICHARDS has joined Astrodyne as a senior engineer in the Engineering and Development Dept.

MEL S. NIELSEN, appointed western division manager, Truarc Retaining Rings Div., Waldes Kohinoor Inc.

ROBERT MÓRAN, named general manager, Defense and New Products Division, The General Tire & Rubber Co. ROBERT E. MAHAN has been promoted from manager of sales engineering to sales manager of the division.

DONALD K. SAMPSON has joined Telex Inc. to assist in setting up a new Systems and Military Products Div.

SAMUEL H. CANTWELL, named manager of administration at the Missile Development Laboratory, Minneapolis-Honeywell Regulator Co.

ROBERT C. PERRY, appointed government contracts administrator, New Products Div., Corning Glass Works.

DR. HARRY P. KLING has been named manager of the Nuclear Components Dept. of the Martin Company's Nuclear Div.

RICHARD W. LEE, elected president of General Precision Laboratory Inc.

H. DOUGLAS LOWREY, named assistant general manager of Chrysler Corporation's Missile Div.

STANLEY W. SMITH, who supervised development and construction of the Bell X-1 and X-2, has joined the Fairchild Engine & Airplane Corp. as chief engineer of the Aircraft and Missiles Div.

RICHARD W. SWEENEY, named assistant manager of market development for aircraft and missiles, Mallory-Sharon Metals Corp. He will be active in expanding the market for titanium.

DR. ITALO S. SERVI, appointed as director of research, Metals Div., Kelsey-Hayes Co.

R. C. CHILTON, named vice president-development planning of Horkey-Moore Associates.

WILLIAM A. WILKINSON, appointed supt. of manufacturing, Arnoux Corp.

W. W. HARRIS, now corporate director of contracts with the American Bosch Arma Corp.

HUGH C. BREAM, appointed manager of the Santa Barbara Div. of Western Design.

JOSEPH YAMRON has joined Hamilton Standard, division of United Aircraft Corp., as project engineer in charge of flight control systems.

WILLIAM B. BERGEN, now president of the Martin Co. A. J. PERRY, named asst. sales and service director, Baltimore Div.

H. Douglas Lowrey
Chrysler

Stanley W. Smith
Fairchild

Dr. Italo S. Servi
Kelsey-Hayes

R. C. Chilton
Horkey-Moore

Joseph Yamron
Hamilton Standard

William B. Bergen
Martin

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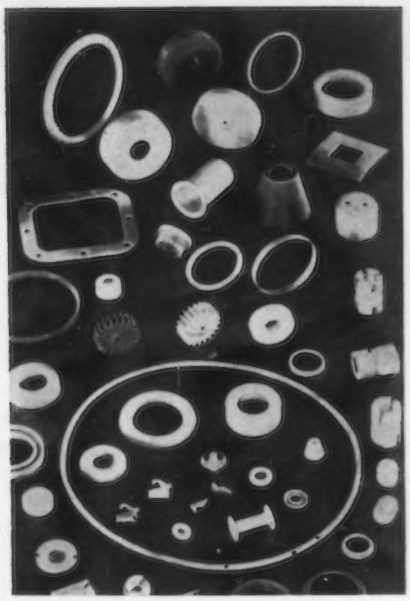

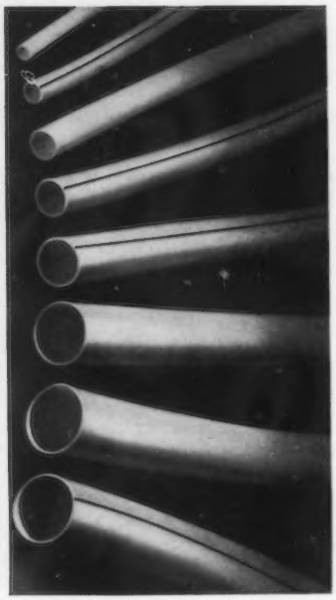

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PITTSBURGH 22 • SAN FRANCISCO 5 • SEATTLE 4 • PETERBOROUGH, ONTARIO, CANADA

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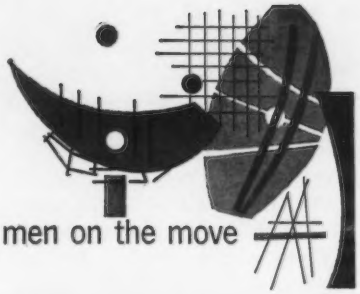
Brake Blocks • Clutch Facings • Laundry Pads and Covers • Industrial Adhesives • Bowling Balls



John B. Darrah
The Budd Co.

John H. Rubel
Dept. of Defense

JOHN B. DARRAH, appointed Vice President and General Manager of The Budd Company's Defense Division.

JOHN H. RUBEL, appointed assistant director of Defense Research and Engineering (strategic weappons), Defense Dept. Rubel, 39, has been granted a leave of absence from Hughes Aircraft Co., where he has been director of airborne systems laboratories.

GEORGE S. CHERNIAK, appointed Director, Space Technology Laboratories, Inc., Flight Test Operations at the Atlantic Missile Range, Cape Canaveral, Fla.

JAMES V. CRAWFORD, appointed chief engineer, AiResearch Mfg. divisions, The Garrett Corp. NORMAN H. BROWN, appointed assistant chief engineer.

DR. MAX T. WEISS has joined Hughes Aircraft Co. as senior staff physicist of the microwave laboratory's electronic research department.

J. J. DALL, appointed assistant general manager, Electric Welding, Linde Co.

Dr. Max T. Weiss
Hughes Aircraft

J. J. Dall
Linde

Electrical Connectors

Catalog on "DS" series of miniature electrical connectors with snap-in contacts and crimp-type terminations.

The Deutsch Co.

Circle 82 on postcard for more data

Aircraft and Missile Products

Illustrated booklet of equipment.

Aviation Div.
Walter Kidde & Co.

Circle 99 on postcard for more data

Weights and Measures

Catalog of equipment for weights and measures officials.

W. & L. E. Gurley

Circle 107 on postcard for more data

Test Equipment

Catalog lists line of test equipment plus pertinent engineering data.

A. M. Guardite
Div. of American-Marietta Co.

Circle 104 on postcard for more data

Parts Catalog

55-page catalog of standard parts: lugs, washers, terminals, etc.

Zierick Mfg. Corp.

Circle 78 on postcard for more data

High Temperature Metals

Booklet on high temperature metals: properties and processing data, charts, selection.

Universal-Cyclops Steel Corp.

Circle 90 on postcard for more data

Molybdenum Pricing

Pricing schedule for molybdenum and molybdenum-titanium alloys.

Refractomet Div.
Universal-Cyclops Steel Corp.

Circle 98 on postcard for more data

Engineering Manual

88-page design manual describes line of standard clamps, line supports, brackets, and shims.

TA Mfg. Co.

Circle 89 on postcard for more data

Missile Switches

Comprehensive reference catalog on basic missile switches and actuators.

Electrosnap Corp.

Circle 102 on postcard for more data

Servo Systems

Six-page bulletin describes activities in the field of electro hydraulic servo systems and components.

Eastern Industries Inc.

Circle 103 on postcard for more data

Avionics Division

Catalog describes complete facilities and products of firm's Avionics Division.

Electronic Specialty Co.

Circle 83 on postcard for more data

worth asking for:

technical literature listed here is available without charge from the various manufacturers

Epoxy-Reinforced Plastics

Technical release No. 7 describes new fast-cure epoxy systems and their newly developed spray equipment.

Union Carbide Plastics Co.

Circle 96 on postcard for more data

Pressure Switch Catalog

36-page design handbook and catalog.

Barksdale Valves

Circle 79 on postcard for more data

Facilities Brochure

Brochure describes facilities for producing deep drawn parts and metal stampings.

Peterson Products Corp.

Circle 85 on postcard for more data

Plate Reactor Metals

Technical bulletin describes forms and sizes of general plate reactor metals—boron-stainless steel alloys, hafnium, niobium, tantalum, vanadium, zirconium and zircaloy.

Metals & Controls
Div. of Texas Instruments Inc.

Circle 91 on postcard for more data

Torquemeters

Two-page bulletin describes Series 85 Torquemeters for measuring dynamic torques.

Metron Instrument Co.

Circle 105 on postcard for more data

Cessna

Illustrated brochure of firm's commercial and military aircraft gives listing, specification and performance figures.

Cessna Aircraft Co.

Circle 80 on postcard for more data

Micronic Filtration

Brochure describes facilities in micronic filtration.

Bendix Filter Div.
Bendix Aviation Corp.

Circle 93 on postcard for more data

Beryllium Copper Alloys

Full information on beryllium copper 10, 25, and 165 alloys.

Pennrold Div.
The Brush Beryllium Co.

Circle 77 on postcard for more data

Hi Temp Magnet Wire

Brochure on ceramic insulated magnet wire for service up to 1000°F.

Secon Metals Corp.

Circle 88 on postcard for more data

Structural Components

Brochure shows production processes for structures, sub-assemblies and other components.

Prewitt Aircraft Co.

Circle 81 on postcard for more data

Mounting Systems

Bulletin, "Mounting Systems Capabilities."

Lord Mfg. Co.

Circle 94 on postcard for more data

Aluminum Machining

Tables of feeds, speeds.

Peter A. Frasse & Co.

Circle 87 on postcard for more data

Facility Brochure

16-page brochure describing design, engineering, and manufacturing facilities.

American Aluminum Co.

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continued on next page

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worth asking for:

technical literature listed here is available without charge from the various manufacturers

Hi-Temp Mg Alloys

"Shop Guide for Elevated-Temperature Magnesium Alloys" describes best methods of working magnesium alloys of the thorium and rare-earth-metal families.

Magnesium Products Sales Dept.
The Dow Chemical Co.

Circle 92 on postcard for more data

Seals and Fasteners

Catalog illustrates line of single-unit, high-pressure seals and fasteners.

APM Corp.

Circle 100 on postcard for more data

Electronic Weighing

12-page booklet on "Industrial Weighing Through Electronics."

Streeter-Amet Co.

Circle 106 on postcard for more data

Plastics

64-page catalog on line of plastic sheets, rods, tubes, films, blocks, and flat tubings.

Cadillac Plastic & Chemical Co.

Circle 95 on postcard for more data

Silicon Carbide

Technical Data Sheet lists description, properties, erosion test results, and fabricability of Silicon Carbide (Bonded Graphite).

Research & Development Div.
The Carborundum Co.

Circle 101 on postcard for more data

Lab Instruments

Brochure tells how to select and use electrical measuring instruments in experimental laboratories.

Weston Instruments Div.
Daystrom Inc.

Circle 86 on postcard for more data

Potentiometers

Catalog presents electrical, mechanical, and environmental specs, outline drawings and coil data for all production model Helipot precision potentiometers, associated turns-counting dials, and delay lines.

Helipot Div.
Beckman Instruments Inc.

Circle 97 on postcard for more data

industry notes

BRINGING A SPACE CAPSULE DOWN

Project Discoverer's re-entry vehicle — a miniature space capsule containing animal life—is set free from its parent orbiting nose cone by explosive bolts operating on signal from a timer.

Capsule drifts at a small differential velocity beneath the satellite proper, which consists of Lockheed's cylindrical magnesium second stage and General Electric's ablative nose cone.

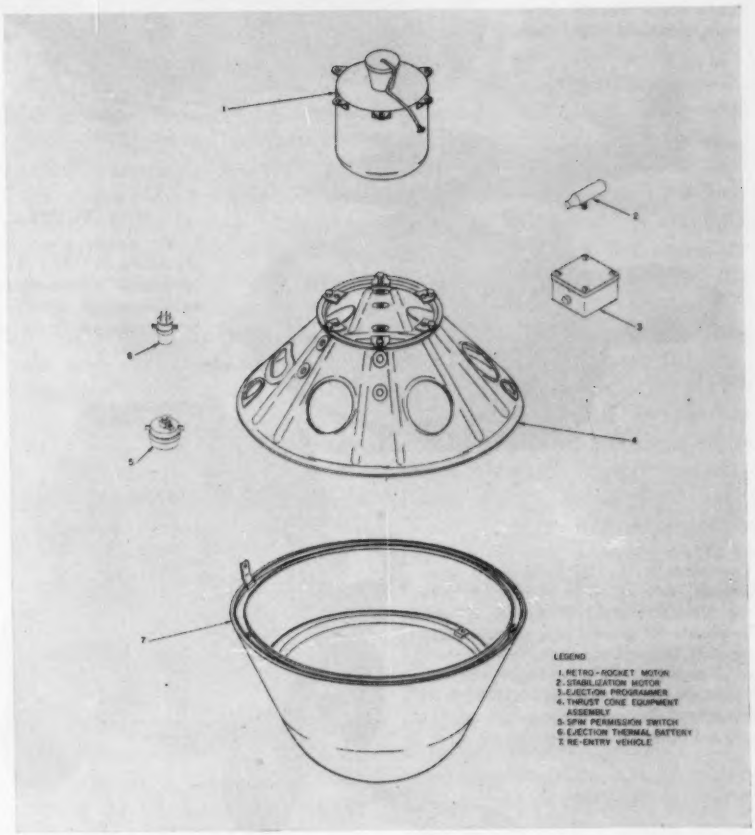
A few seconds after separation, spin rockets in the capsule go off, revolving the package, designed and built by General Electric's Missile and Space Vehicle Dept. under subcontract to prime contractor Lockheed, to about 60 rpm.

Compressed gas jets had pointed the capsule to earth before it left the satellite. Now that it is also spinning (averaging out the differential between the center of gravity and the center of thrust of the recovery mass) re-entry can begin.

A timer in the package fires a retro-rocket. The capsule is thus slowed for a very slow, shallow re-entry at an angle less than five degrees.

Re-entry vehicle is generally based on the Thor-Able ablative nose cone. But it is much thinner and lighter (195 lb on separation). Re-entry also must be slow so a parachute can be effective.

When the package reaches a certain depth in the atmosphere, the retro-rocket and a portion of the capsule's aft end is thrown off. A switch operated by forces of deceleration releases a parachute. Protective ablative heat shield (which had been sort of a nose



CAE...

PRODUCERS OF SPECIALIZED POWER

J69-T-29A

1,700 lb.-thrust model for drone applications. The new engine has 60% more thrust with only a 6% increase in weight. It is presently powering the Ryan Q-2C target drone which recently underwent successful flight tests.

J69-T-25

Latest power plant for the Air Force T-37A twin-jet trainer manufactured by Cessna, the J69-T-25 has increased thrust to 1,025 lbs.

Continental's TC-106 turbine air compressor, developed in conjunction with the United States Air Force, is now available for ground support of jet age aircraft. The unit, supplying low pressure air, is especially suited to engine starting, cabin air conditioning and actuation of electrical generating equipment for ground operations of the aircraft.

CONTINENTAL AVIATION & ENGINEERING CORPORATION

12700 KERCHEVAL AVENUE, DETROIT 15, MICHIGAN

SUBSIDIARY OF CONTINENTAL MOTORS CORPORATION

cone within the main nose cone) falls away.

Going the rest of the way down until they are caught by C-119 aircraft or fall into the sea: a life cell within a flotation cell.

Life cell is a rectangular magnesium box weighing less than 15 lb. It has a curved top so that it looks coffin-shaped. It rests within a spun aluminum flotation bucket. Latter is a hemisphere with a flat rear cover where parachute is held.

The magnesium box containing mice or, probably this summer, a Rhesus monkey, forms a closed cycle, ducted life support system—the basic form for manned re-entry from orbit.

Within the cell, a pop-bottle-size air conditioning system circulates pure oxygen, removes CO_2. Humidity, oxygen, and pressure are exactly regulated. Respiration absorbers for four mice in Discoverer III: 60 grams LiCl for CO_2, 110 grams LiOH for water vapor, 3½ grams activated charcoal for purification.

Mag Life Cell . . .

During orbit, Discoverer's thin-magnesium life cell has ½ atmospheric pressure inside, none outside.

During re-entry, outside and inside pressures equalize.

At sea level, there is again a half atmosphere differential: one atmosphere outside, ½ atmosphere inside. The differential works out to about one ton of load.

The life cell must be a pressure vessel in both directions—to counter the crushing effect at sea level and the ballooning effect in orbit.

Careful control of existing techniques was exercised by Chalmers-Kubek, Brookhaven, Pa., who fabricated the cell under subcontract from General Electric. This entailed heat forming of Mg at about 600°F, stress relieving at about 350°F.

Support framework was welded for structural strength before joining to life cell.

Re-entry vehicle is of special ablative material. It weighs 195 lb as it begins its plunge.

Magnesium was made corrosion proof against salt air and water, animal wastes, and chemical air purificators. Cell was sealed with MIL std 27B polyester impregnation. Semi-ceramic coating was electro-deposited on the magnesium with the HAE immersion process. Standard Dow treatments (MIL M 3171 A) were used on components inside the cell.

ARMY LISTS PRIORITIES

Present priority list for aircraft being developed by the Army:

Top Priority — the **Mohawk,** twin-turboprop fixed-wing observation aircraft. Priority 2—the **Iroquois,** turbine-driven helicopter. Priority 3—the **Caribou,** 3-ton payload STOL. Priority 4—the **Chinook** transport helicopter.

PROMISING PROCESS FOR MOLYBDENUM

The use of molybdenum at temperatures above 2000°F may soon be possible in jet and rocket engines as a result of a new surface treating process called Chromalloy W-2.

It has been difficult to take advantage of molybdenum's excellent high temperature strength because at temperatures above 1000°F in an oxidizing atmosphere a volatile oxide (MoO_3) is formed which produces an extremely rapid oxidation rate in the pure base metal. Oxidation rates between 0.58 and 0.92 gm per sq cm per hr have been observed at 1750°F. Unprotected molybdenum has been practically useless as a structural material above 1000°F.

Treatment by the Chromalloy W-2 process, which involves a diffusion of chromium into the surface, provides molybdenum with a degree of oxidation resistance that makes it more promising for such considered applications as gas turbine blades, ram jet flame holders, turbine wheels, nuclear reactor rods, and various rocket engine components.

Ordinarily the most desirable approach to the problem of rapid oxidation would be to alloy the metal. Although alloys have been developed which possess an oxidation rate 100 times lower than pure molybdenum, the oxidation resistance is still not acceptable by metallurgical standards.

Millions have been spent in developing ceramic, spray and electroplated coatings. None has provided an acceptable amount of oxidation resistance in balance with good impact and bend tests.

Chromalloy has not been evaluated extensively enough to pass on the ultimate worth of the process, but initial tests are promising. Tests conducted by Climax Molybdenum Co. used a Globar heated furnace in moving air. W-2 treated molybdenum met temperature cycles above 2000°F without evidence of oxidative failure.

Climax has tested W-2 Chromallized panels of 0.5 per cent titanium - molybdenum by heating in a gas-air flame to a temperature of 1800°F in 30 sec, holding that temperature for 15 sec, then cooling in an air blast to room temperature in 45 sec. After 2000 heating and cooling cycles there was no failure. A government agency has conducted tests in which Chromallized molybdenum tubing has been exposed to steam at 2500°F for six hours, again without failure.

Another promising application of the Chromalloy W-2 protective alloy surface is with niobium. Although this metal does not form volatile oxides, it must still be protected against oxidation to preserve its inherent high temperature strength properties. With the new surface treatment, niobium has been tested at 1800°F for 320 hr with thirteen heating and cooling cycles without failure.

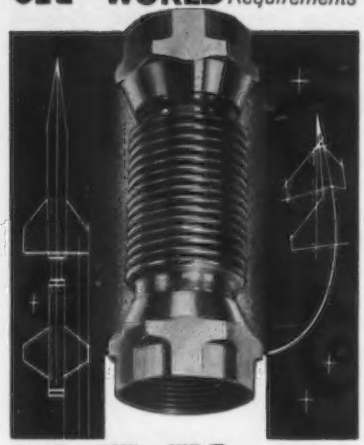
Molybdenum, which doesn't melt until it reaches about 4,748°F, forms a volatile oxide at much lower temperatures.

Unless countermeasures are taken, molybdenum parts of a space-craft re-entering the atmosphere would literally "go up in smoke."

Besides reducing the oxygen content of the metal, special surface treating can overcome this oxidation danger. One process permitting use of molybdenum above 2000°F is "W2" of the Chromalloy Corp.

(Another protective of nickel over chromium coating has been devised by National Bureau of Standards researchers for the Navy Bureau of Aeronautics. It prevents oxidation for more than 1,000 hr at 1,800°F.)

UP to OUT-OF-THIS WORLD Requirements



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Reverse Countersinks

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CONTRACT AWARDS

The Martin Company's Orlando Div. will continue producing Lacrosse surface-to-surface missiles and engineering services under new Army contracts totaling $15,181,000. First two battalions to be equipped with Lacrosse have just been activated.

Sparse manufacturing details—but no dollar values on the contracts—were revealed on Minuteman ICBM. The Utah Div., Thiokol Chemical Corp., awarded an undisclosed contract to the Budd Co. for constructing solid propellant rocket engine cases for the program. Budd will join new AM-355 high alloy steel through a patented method of joining by resistance and fusion welding.

The Allison Div. of General Motors will develop first and second stage large metal cylinders for Minuteman's solid fuel propellant under a joint development program with Thiokol.

Aerojet General granted Hydrodyne Corp. contracts for Minuteman nozzle assemblies. This new work on three types of nozzles utilizes special high-temperature materials.

It has been revealed that ARPA has placed the bulk of its satellite contracts with Lockheed Aircraft Corp., prime contractor for Discoverer, Midas, and Sentry. ARPA has awarded Lockheed $239,938,000 in all, mostly for bringing reconnaissance satellites to operational status.

Beech Aircraft won a Navy and Air Force design competition among 18 manufacturers for KD2B-1 missile target operating from 5,000 to 70,000 ft., flying eight minutes at Mach 1.5, five minutes at Mach 2. Target is planned to be operational by 1962.

In aircraft contracts, Los Angeles Div., North American Aviation, awarded a multi-million-dollar contract to the Garrett Corp.'s AiResearch Manufacturing Div. for developing and manufacturing the Mach 3 B-70's central air data system. AiResearch last November won a contract to develop a similar system for the F-108 Interceptor.

The Avionics Div., John Oster Mfg. Co., will develop and manufacture a new type "easy reading" instrument system for in-flight monitoring of the B-70's high thrust engines—also under Northern American Aviation subsystem contract. General Electric Co. will supply electrical power generating systems and engine starter sub-systems for the B-70 — with the next year devoted almost exclusively to engineering development and prototype manufacture. Contract was awarded by Sundstrand Aviation, secondary power sub-systems manager on the project.

Air Materiel Command awarded General Electric a five-million-dollar contract for production of J79 turbojet engines for Lockheed F-104 Starfighters slated for the Federal Republic of Germany. AMC awarded Hughes Aircraft a $3-million contract for aircraft and weapons control systems, engineering services, materials, and data.

Westinghouse Electric Corp.'s aircraft equipment department, Lima, Ohio, was awarded a production contract approximating $11 million to manufacture electrical power generating systems for the Air Force B-58 Hustler. Contract was awarded by Convair Division of General Dynamics Corp.

Other Contracts:

$7-million Navy contract

to Westinghouse Electric Corp. for continued production of hard-to-jam advanced shipboard radio transmitters.

$470,000 contract to Curtiss-Wright Corp., Santa Barbara, for engineering and fabrication of the new TDU-12/B Skydart I rocket target.

Princeton University awarded contracts for design and construction of a 36-inch-aperture telescope — considered a direct technical forerunner of satellite astronomy—to Perkin Elmer Corp.

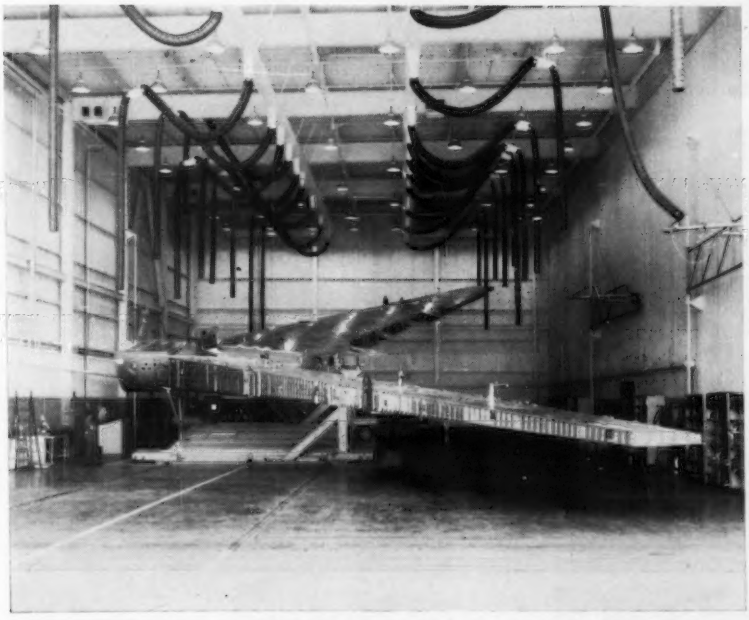
Collins Radio Co. awarded ACF Industries $434,805 contract to produce Avion radar beacons for the Project Mercury manned capsule. A $46,356 NASA contract went to Space Electronics Corp. to study requirements for a Control Center for Project Mercury.

Callery Chemical Co. received a U. S. Air Force contract to supply Hi Cal, boron-based high energy fuel, for a classified military project, and a $175,000 NASA contract for a new, classified rocket propellant.

The Navy Office of Naval Research and Air Force Office of Scientific Research awarded Republic Aviation Corp. contracts totaling $193,000 for advanced experimentation in two major areas of development of a magnetic pinch plasma space ship engine. Republic hopes to solve the continuous cycling problems by 1960, and accomplish a production model by 1964. The firm also received over $300,000 in defense contracts for research and development on ballistic missile defense systems. The Air Force awarded Republic $121,000 to develop and install a prototype hook to enable fighters to land on very short runways.

NASA contract is expected to be awarded this month for worldwide Project Mercury tracking - communications - data processing network.

SEALING UNLIMITED



Completed 139 ft, nine inch integral wing of Douglas DC-8 is shown in sloshing area where integral fuel tanks are filled with 9,600 gallons of sealant. Wing is tilted approximately 12 deg up and down to slosh sealant (Minnesota Mining & Manufacturing's EC-T16MIBK) over tank area. Cured for 30 minutes with 120°F air from overhead ducts, sealant forms effective leakproof seal

STRUCTURES ENGINEERS

Exceptional opportunities are available for Structures Engineers on our B-70 and F-108 weapon systems and X-15 manned space aircraft.

Stress Analysis— Rigorous design requirements necessitate extensive structural investigation of the influence of high temperatures and unconventional external loadings. Stress engineers concerned with such structures will have the opportunity to utilize their technical knowledge to the fullest extent in the development of new analysis methods.

Load Analysis—Corresponding demands on the structural loads engineer have also created unique careers with significant potential in the fields of dynamic loads, aeroelastic loads, loading spectra, flight load data analysis, and digital and analog computer programming.

Weight Analysis— Exacting air vehicle performance requires the optimization of structural design layouts to produce the lightest weight configurations. Weight engineers with experience in stress analysis are required for the formulation of advanced weight estimation and control procedures.

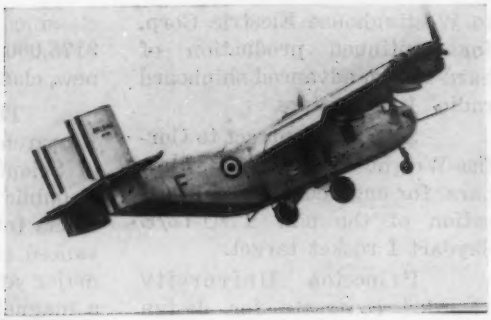
For details about these positions please write: Mr. L. G. Stevenson, Engineering Personnel, North American Aviation, Inc., Los Angeles 45, California.

THE LOS ANGELES DIVISION OF

NORTH AMERICAN AVIATION, INC.

industry notes

Breguet unveils four engine STOL



The Breguet 940 in flight. Each engine runs at 34,500 rpm, drives a free turbine at 24,000 rpm; this being reduced to 3,545 rpm and fed directly into the cross shaft. Alternate version, the 941, is planned as 20 ton vehicle.

Experimental four engine STOL transport, the Breguet 940, is making test flights in France. Seven-ton aircraft is based on the deflected slipstream concept, with "super" flaps and four interconnecting propellers. Designed and built by Breguet Avions, the 940 can land in less than 250 ft, clear a 50 ft obstacle in less than 350 ft. The 12.4 ft diam propellers are driven by a common transverse shaft in wing leading edge. Pitch of propellers is electrically controlled and synchronized by shafting from actuator and synchronizer in center section. By agreement with Breguet, Piasecki Aircraft has sales rights to the craft in the U. S.

View of wing-tip underside shows aileron hinge arrangement. Ailerons operate independently or in conjunction with flaps.

Four 400 hp Turbomeca Turmo II turboprops power the 940 "Integral." Propellers are built by Breguet; transmission is by Potez.

FACILITIES

Cooper Industries, aircraft parts distributor, will move offices and warehouse facilities to Elk Grove, Ill. about August 1.

Texaco, Inc. will operate Experiment Inc. high-energy fuel research organization as a wholly-owned subsidiary.

Induction Motors Corp., Westbury, L. I., has changed name to **IMC Magnetics Corp.** and has acquired **Mason Electric Corp.** of Los Angeles.

Linde Co. will build and operate a plant for production of liquid hydrogen at Torrance, Calif. Linde's Pittsburg, Calif. plant for production of liquid oxygen and liquid nitrogen has opened one month ahead of schedule.

Authorities in automatic programming of electronic data processing systems have formed **Computer Sciences Corp.,** Los Angeles, to serve computer users and manufacturers.

Hupp Corp. has purchased the valve operator division of **Cutler-Hammer, Inc.** Manufacturing operations will be moved from Milwaukee to the Chicago plant of the Hupp Aviation Co. division.

New Anti-Submarine Warfare Dept., has been established at **Magnavox Co.** Firm is developer of ASW sonobuoys.

Acoustica Associates, Inc. has acquired the **Universal Dynamics Corp.,** Santa Barbara, Calif. manufacturers of piezoelectric ceramics used in ultrasonic and sonar equipment.

Arwood Precision Casting Corp. is expanding or modernizing all four of its plants which produce ferrous and non-ferrous investment castings.

Century Electronics & Instruments, Inc. and the **Aviation Division** of **Spartan Aircraft Co.** are combining aircraft and electronics capabilities and facilities.

Martin's Nuclear Div., Baltimore, is operating a new **PM-1 Product Dept.** to direct work on the PM-1 portable powerplant being built for the AEC.

Rheem Mfg. Co. has sold its Downey and Riverside, Calif. facilities to **Aerojet General Corp.** for an undisclosed cash sum.

Boeing Aircraft's seventh operating wind tunnel is slated for completion this month at Seattle. It will test models at Mach 10 to 27. Arc of five million amperes will heat compressed air in "hot shot" tunnel to 18,000° F and 30,000 psi.

OUTLOOK—MATERIALS AND PROCESSES

MA-356 high-purity aluminum casting alloy with high physicals has been developed to save weight in sand and permanent mold castings for missiles and jet aircraft. Developer: Rolle Mfg. Co., Lansdale, Pa.

In the developmental pilot plant stage at Alloyd Research Corp.: improved process for **vapor phase deposition of chromium, molybdenum and tungsten** to produce adherent coating of the metals on substrate materials. Heavy coating of tungsten on graphite appears possible for missile and rocket nozzles.

Corning Glass Works has developed **lightweight sandwich construction of Pyroceram glass-ceramic** for mirror blanks for outer space telescopes. Short lengths of Pyroceram tubing between two flat pieces of Pyroceram give needed rigidity despite extreme temperature changes.

The Air Force is delivering **king-size steel sheets** to 16 aircraft, missile, and propulsion manufacturers for applications evaluation. Program, sponsored by Manufacturing Methods Div., Aeronautical Systems Center, Air Material Command, takes advantage of U. S. Steel Corp. rolling process for high strength steel alloys.

Developed for the aircraft industry, a new **scratch-resistant coating,** Zincilate WST-100, protects polished surfaces temporarily, can be removed with warm rinse. Developer: Industrial Metal Protectives, Inc.

Glass melamine laminated plastic developed by Formica Corp. retains 70 per cent of its dielectric strength after being immersed in water 336 hours at 50°C; 50 per cent after 1,000 hours immersion.

Dirty solid propellant grain gases have been used to operate a hot servo for periods longer than two minutes at General Electric's Light Military Electronics Dept., Johnson City, N. Y.

Acidic detergent, Oakite Compound No. 86, is being introduced by Oakite Products, Inc., for cleaning steel and simultaneously improving its resistance to corrosion and receptivity to paint.

Urethane foam is being used to construct wind tunnel test models which can be easily weighted to study effects of inertial distributions.

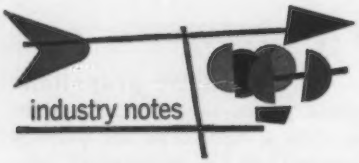
Injection moulded acetal resin components are being produced by Gries Reproducer Corp., New Rochelle, N. Y. One advantage of this "Delrin" resin: good overall creep resistance.

Field test by a leading aircraft research center and Sun Oil Co. indicates that **antileak oils** can reduce hydraulic fluid losses as much as 35 per cent. Test involved centralized lubrication and hydraulic system for equipment servicing high speed tunnels and test stands.

Look for Wyman-Gordon to propose that government sponsor a detailed R & D program in **forging special alloys and shapes.** W-G will ask primes to anticipate needs; government to fund "extension of the forging art." Materials under study would include tungsten, tantalum, beryllium, chromium.

Rogers Corp., producer of wave-guide antennas by the "water dispersion process," will soon introduce a **new acrylic material.**

✦



TERRA-SCOPE

Polaris note: though extra funds probably won't be added for procurement and outfitting of Polaris subs, the Navy still has authority to complete nine Polaris-firing subs and start work on three others.

•

Scientists at Battelle Memorial Institute report that chemical reduction seems the best system to date for freeing oxygen from exhaled carbon dioxide in a space ship. A reducing agent would convert CO_2 into solid carbon. Then O_2 would be recovered as a gas.

•

The Smithsonian Optical Tracking Station at Woomera, Australia, has photographed Vanguard I at its apogee 2,500 miles from Earth—a feat comparable to aiming a camera at a golf ball 600 miles away.

•

The H-1 liquid propellant rocket engine which, in cluster of eight, will give 1,500,000-lb thrust to ARPA's Project Saturn is modified so it is more compact than the Jupiter and Thor engines on which it is modeled. First of the Rocketdyne H-1's has been delivered to Redstone Arsenal.

•

NASA is using five of Chance Vought's Crusader III fighters for research on noise problems in supersonic aircraft, automatic pilot projects and high speed tracking by radar.

The Bonn Government has made an agreement with Lockheed Aircraft to buy 75 finished F-104 Starfighters, build 225 under license. The 225 will be built by Heinkel-Messerschmidt.

•

The Air Research and Development Command has made the first wind tunnel test of a full-scale guided missile with its powerplant in operation. Test occurred at the Propulsion Wind Tunnel of the Arnold Engineering Development Center. Missile was McDonnell's GAM-72 Quail.

•

"The Flutter Dart," rocket test vehicle developed by Armstrong Whitworth Air-

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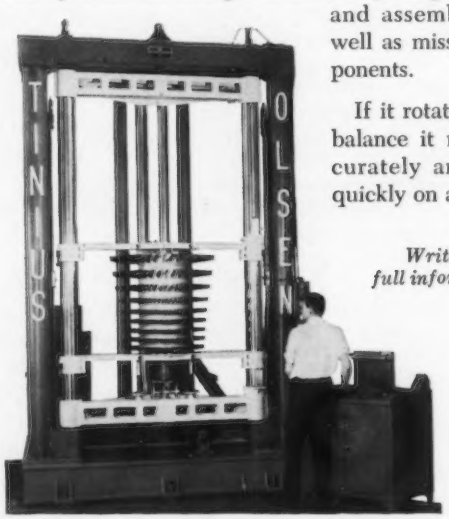

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craft, is being used to study effects of supersonic flight on wing and control surfaces. Tests are studying the design trend for the first British supersonic airliner.

•

Piasecki Aircraft Corp. has begun an advanced research and development program on "Medio-Wave" underwater communication and detection system. Transmission, by electromagnetic means, could also reportedly be used through the earth's surface. Piasecki acquired manufacturing rights, and license to all patents, from Medio Corp. of America, Keasbey, N. J.

•

Convair Astronautics is operating a 93-ton Cyril Bath radial stretch former with hydraulic-driven turntable to stretch stainless steel sheets into skins for Atlas ICBM. Machine eliminates much previous welding of metal pieces.

•

Deionized water is being used for "wet takeoffs" by Pan American 707 jetliners. Injected into a jet engine at takeoff, the water can increase thrust enough to raise gross takeoff weight 10 to 15 per cent.

•

Ballard Aircraft will modify its Burnelli "lifting body" Loadmaster I prototype for manufacture and sale as low-operating-cost Loadmaster II. It will develop and manufacture a similar aircraft of 30,000 lb payload as Loadmaster III.

•

First group of launching complexes for Atlas ICBM is being constructed at Warren AFB near Cheyenne. Atlases will be stored in a horizontal position for greater protection. Westinghouse Electric Corp. has developed the control system for erecting the missile in two minutes.

•

Full scale tactical sustainer motor for Nike Zeus antimissile missile was successfully static fired. Motor was developed by Grand Central Rocket Co. for Douglas Aircraft. Motor has thin walled motor case, and a Douglas-developed heat resistant plastic nozzle.

•

Office of Technical Services has available two reports on the Navy's Perceptron discriminating machine. PB 151247 covers design. PB 151247-S covers the changes which made it "the first machine capable of having an original idea."

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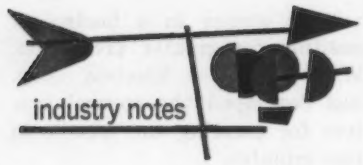

INDUSTRY STATISTICS

Source: Bureau of the Census and Federal Aviation Agency.

VALUE OF NET SALES, NEW ORDERS, AND BACKLOG OF COMPLETE AIRCRAFT, AIRCRAFT ENGINES, AND PROPELLERS

All data are in Thousands of Dollars

Product and Type of Customer	NET SALES First Quarter		NEW ORDERS First Quarter		BACKLOG First Quarter	
	1959	1958	1959	1958	1959	1958
Complete aircraft and parts						
For U. S. Military customers	$ 989,000	$1,410,000	$ 892,000	$1,443,000	$ 5,310,000	$ 6,470,000
For other customers	258,000	297,000	106,000	170,000	2,536,000	2,672,000
Total	$1,247,000	$1,707,000	$ 998,000	$1,613,000	$ 7,846,000	$ 9,142,000
Aircraft engines and parts						
For U. S. Military customers	$ 353,000	$ 465,000	$ 166,000	$ 215,000	$ 1,292,000	$ 2,129,000
For other customers	83,000	80,000	71,000	92,000	527,000	602,000
Total	$ 436,000	$ 545,000	$ 237,000	$ 307,000	$ 1,819,000	$ 2,731,000
Aircraft propellers and parts						
For U. S. Military customers	$ 14,000	$ 40,000	$ 13,000	$ 9,000	$ 46,000	$ 95,000
For other customers	10,000	10,000	6,000	5,000	18,000	27,000
Total	$ 24,000	$ 50,000	$ 19,000	$ 14,000	$ 64,000	$ 122,000
Total—For U. S. Military	$1,356,000	$1,915,000	$1,071,000	$1,667,000	$ 6,648,000	$ 8,694,000
Total—Other customers	$ 351,000	$ 387,000	$ 183,000	$ 267,000	$ 3,081,000	$ 3,301,000
Other products and services	$ 851,000	$ 556,000	$ 838,000	$ 717,000	$ 2,976,000	$ 2,329,000
Total—All Products	$2,558,000	$2,858,000	$2,092,000	$2,651,000	$12,705,000	$14,324,000

NUMBER AND VALUE OF CIVIL AIRCRAFT SHIPMENTS

Month	Units		Value in Thousands	
	1959	1958	1959	1958
January	665	582	$ 49,590	$ 63,249
February	619	518	49,805	67,515
March	736	708	34,014	38,417
April	745	708	68,142	48,677
May	.....	630	.....	37,616
June	.....	592	.....	26,421
July	.....	503	.....	41,587
August	.....	471	.....	30,776
September	.....	399	.....	24,401
October	.....	628	.....	49,328
November	.....	531	.....	34,881
December	.....	612	.....	37,672
Total—Year	.....	6,882	.....	$500,540
Total—4 Mos.	2,765	2,516	$201,551	$217,858

AIRFRAME WEIGHTS OF CIVIL AIRCRAFT SHIPMENTS

Month	Thousands of lbs.		Avg./Aircraft	
	1959	1958	1959	1958
January	1,452.8	1,932.0	2,185	3,320
February	1,440.0	1,951.7	2,326	3,768
March	1,185.7	1,397.0	1,611	1,973
April	1,849.6	1,635.8	2,483	2,310
May	.....	1,356.6	.....	2,153
June	.....	1,093.1	.....	1,846
July	.....	1,418.7	.....	2,820
August	.....	1,106.0	.....	2,348
September	.....	855.2	.....	2,143
October	.....	1,545.6	.....	2,461
November	.....	1,107.1	.....	2,085
December	.....	1,258.9	.....	2,057
Total—Year	.....	16,657.7	.....	2,420
Total—4 Mos.	5,928.1	6,916.5	2,144	2,749

SHIPMENTS OF PISTON ENGINES FOR CIVILIAN AIRCRAFT

Month	Units		Value	
	1959	1958	1959	1958
January	873	1,033	$ 2,635,000	$ 8,883,000
February	954	1,139	2,729,000	9,696,000
March	921	994	2,613,000	8,174,000
April	947	881	2,728,000	8,174,000
May	.....	828	.....	6,176,000
June	.....	783	.....	5,994,000
July	.....	730	.....	4,898,000
August	.....	693	.....	3,420,000
September	.....	757	.....	3,312,000
October	.....	811	.....	3,336,000
November	.....	786	.....	2,815,000
December	.....	798	.....	2,965,000
Total—Year	.....	10,233	.....	$ 67,843,000
Total—4 Mos.	3,695	4,047	$ 10,704,000	$ 34,927,000

TOTAL HP. OF AIRCRAFT PISTON ENGINE SHIPMENTS FOR CIVILIAN USE

Month	Total Hp. (in Thousands)		Avg. Hp. per Engine	
	1959	1958	1959	1958
January	196.2	468.9	225	454
February	206.7	518.2	217	455
March	197.7	440.7	215	443
April	205.1	428.0	217	486
May	.....	338.3	.....	409
June	.....	328.7	.....	420
July	.....	282.1	.....	386
August	.....	210.0	.....	303
September	.....	214.0	.....	283
October	.....	220.9	.....	272
November	.....	198.6	.....	253
December	.....	201.7	.....	253
Total—Year	.....	3,850.1	.....	376
Total—4 Mos.	805.7	1,855.8	218	459

REDUCTION TO PRACTICE OF AIRCRAFT INVENTIONS

by Albert Woodruff Gray

The aircraft-missile industry is producing a wide variety of inventions. Sometimes they result from research investments. Often, a unique idea is hit upon almost by accident, solves a particular design or production problem, and then finds wider industry application.

With this premium on ideas, understanding of Patent Law assumes a new importance.

The concept of a patent —the legal granting of exclusive rights to an inventor—is a fundamental American principle.

Courts have emphasized that a patent is granted for an invention that has been developed from the idea of the inventor. The idea itself cannot be patented. It must be the thing or process representing the idea; not the theory of the airplane but an airplane that will work.

An inventor is entitled to a patent for a successful invention *if* he 1. thought of it first; 2. reduced his thoughts to practice by "reasonable diligence."

Reduction to practice came into play recently when the government tried to overthrow the patent given the inventor of an automatic parachute release.

The government's grounds: a Russian document, reportedly a "prior printed publication," had been secured by the U. S. Embassy in Moscow. However, the U. S. Court of Claims pointed out that "the theory of anticipation by such a publication is that it was available to the public and hence, must be assumed to have been known to the patentee, from which it would follow that the patentee's invention was not new and added nothing to the public knowledge." The Court denied the government's claim.

Another instance of reducing thought to practice: Curtiss Aeroplane and Motor Corp. was awarded a patent for a hydroplane over another claimant because the Curtiss plane actually flew. Cited was "the inventive skill to enable the hydroplane bottom to leave the water and take the last step that counts."

Another time, an inventor constructed a crude radar instrument above a building in Camden, N. J.

Data from the instrument's operation showed smokestacks in the Delaware River. The Federal Appellate Court therefore ruled in favor of a French Patent on a similar device. (The French device was tried later, but more successfully, than the Jersey one.)

On yet another case (on automatic loading of gun cartridges), a court said:

"If intellectual efforts were made to give the idea form, through drawings, models, or machines, but were abandoned before reaching such a stage of completion as to require only ordinary mechanical skill to carry the completion to success, the claim of priority could not be sustained against a later independent conception carried into practical form at an earlier date."

Another time a court held that a wooden model four or five inches long did not constitute proof under the reduction to practice rule.

The great majority of ideas for inventions have little practical application. One aircraft firm estimates that "winners" turn up perhaps once in 5,000 tries. But firms value these so much that many will reward employee-inventors whenever patents on their ideas are granted.

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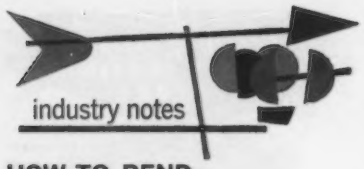

HOW TO BEND TITANIUM TUBING

Titanium, named for a Greek god, has suffered a host of very human troubles since pilot production was begun back in 1946. Not the least of these problems has been bending titanium tubing of the metal.

Yield strength, or resistance to bending, is much greater with titanium than stainless steel. Ductility is much less.

Tubing, however, is being bent sharply now on a radius as small as its own outside diameter. This was never considered practical before. To do so, Kreisler Industrial Corp., Paterson, N. J., draws grade A-40, soft-annealed titanium around a rotating bending form. It is held in position under proper pressure and supported by special moving clamps, dies, and mandrels. Machine operating time and bending cycles are carefully controlled.

The Kreisler technique is a practiced modification of standard bending techniques. The firm follows these basic tenets in using titanium tubing:

- Tubing must be of a soft type with yield strength and ductility suitable for the design.
- Maximum wall thickness must be provided for use and cost, thus providing adequate metal for stretchout at bends.
- Bending should be designed, whenever possible, with minimum radii three times O.D.
- Specify equal, uniform radii for all bends.
- Provide for generous lengths of tubings between bends, cones, other transition, to allow the metal to flow freely despite work hardening.

✦

BOEING'S HIGH TEMPERATURE CERAMIC HONEYCOMB

A recent Boeing-developed technique for manufacturing ceramic honeycomb-sandwich structures may lead to increasing use of ceramics in antenna converings, radomes, and nose cones.

Technique employs thin skins and thin corrugations of high-strength, high-temperature-resistant ceramic oxides. This permits fabrication of ceramic structures similar to metal or plastic honeycomb-sandwich panels.

The ceramic structures are light, strong, and resist temperatures of 3,000 deg. F. They can be mass produced and stand up against rain erosion. (Weight, production difficulties, and electronic limitations have been basic shortcomings of ceramics in more solid forms. Reinforced plastics are vulnerable to aerodynamic heating and rain erosion at high speeds.)

Much of the development work was done with sintered alumina. Other ceramic oxides such as spinel, mullite or fused silica are proving equally good.

To make the ceramic honeycomb, non-plastic, pure oxide materials are finely ground. They are then combined with suitable organic binders and either organic or inorganic liquids into paste form. This material is rolled under heat into thin, dense sheets.

These have properties similar to paper. They are flexible enough to allow sharp bends. Core is shaped by corrugated rolls.

Sheets are rigid enough to retain any given shape. Components are moistened with a thin mixture of the same composition for bonding. When dry, assembly is strong enough to allow considerable cutting and forming.

The ceramic honeycomb assembly, fired in a furnace, emerges as a strong, light, self-bonded unit with a high strength-to-weight ratio, and with the electronic advantages of a sandwich structure.

Other types of honeycomb-sandwich panel structures which may find application in hypersonic vehicles:

- Honeycomb sandwich from ceramic fibers similar to wood pulp. This type is less heat resistant than other ceramic-honeycomb panels but has excellent thermal-shock resistance.
- A phosphate-bonded aluminum oxide, developed in an effort to find ceramic materials with low curing temperatures. Curing temp is only 700°F, important in establishing a production program. Chromium oxide can be added for more strength. To improve resistance to impact and thermal shock, molybdenum wires or screen can be imbedded in the mixture during rolling of the sheet and prior to making the honeycomb core.
- Honeycomb panels may also be made of metal skins brazed to a ceramic core which has been flame sprayed with metal. In this case, the coefficient of thermal expansion of the metal and ceramic core must be matched so the bond won't be pulled apart with changing temperature. Thermal conductivity can be reduced by evacuating the air from within the panel.
- Honeycomb-sandwich panels are now being made from materials such as aluminum oxide and zirconium oxide which withstand temperatures to 2,500°F and 3,500°F respectively. Work is progressing with oxides and carbides of such elements as hafnium and thorium which withstand temperature in 4,000 to 5,000°F range.

✦

readers' orbit

The Case for a Case

. . . In the May issue of your magazine, on page 10 reference is made to "Chromalloy-plate." On page 12, reference is again made to "Chromalloy" in connection with the spider-brace. Then on page 13, appears this sentence: "Welding progresses at the rate of only a few inches at a time. The reason for this is that Chromalloy is readily susceptible to surface corrosion."

My client is the Chromalloy Corporation of 450 Tarrytown Rd., White Plains, N. Y. It is engaged in the business of treating the outside of ferrous metals, following a patented process, to impart to it desirable characteristics, among which, are corrosion resistance. It uses CHROMALLOY as a service mark and has done so for over five years. My client feels that your reference to "Chromalloy" in the forepart of the article, and that the statement on page 13 that "Chromalloy" is readily susceptible to surface corrosion, would indicate to the public that the article is referring to products that have been processed by my client and that these articles are susceptible to surface corrosion. We feel that your references to "Chromalloy" were without knowledge of the above fact, but, nevertheless, we think that you will agree with us that a reader of your article may assume that the reference to "Chromalloy" is to my client, and to the products processed by its Chromalloy process, and that the reader will get the impression that articles processed by my client's Chromalloy process are readily susceptible to corrosion, which is not the fact.

Therefore, on behalf of my client, I request that you publish in your next issue, with prominence at least equal to that of the article to which I object, a statement to the effect that your reference in that article to parts made of "Chromalloy" were intended to mean parts formed of an alloy in which chromium is a constituent, and that there was no intention to imply that they were parts processed by my client's CHROMALLOY process, which parts are actually corrosion resistant.

Daniel L. Morris
Curtis, Morris & Safford

Several years ago the General Electric Co. introduced a chromium-molybdenum-vanadium-iron base alloy which was referred to as "Chromalloy." It was later realized that this name was in conflict with the service mark of the Chromalloy Corporation, which specializes in heat and corrosion resistant finishing. Hence, G E agreed not to use the name "Chromalloy," and the alloy has since been officially identified by the GE specification "B50T1131." However, at the time the article "case of the J-85" was prepared, personnel involved in the project remained conditioned to the original G E trade name for the alloy. As a result, the name "Chromalloy" was erroneously linked with susceptibility to corrosion. The B50T1131 alloy was developed primarily for medium-high temperature service applications, as well as for good welding characteristics; corrosion resistance is not one of its attributes. Therefore, as stated in the article, after the casing is fabricated it is given a protective coating of silicone paint.

Pressure Vessels . . . A Few Suggestions

. . . we are anxious to offer a few suggestions to supplement the information on pressure vessels in your article (May, 1959).

You have said that cylindrical vessels present a more complex fabrication problem, because of the welding needed. We do not think that this is necessarily true, if our drawn cups are used in the vessel. These cups are very easily formed . . . they may be welded together with a single circumferential weld. . . . If an entirely seamless case is required, the open ends of our shells may be economically spun closed, as we make our high pressure vessels (for commercial use.) . . . You also suggest that a better technique than deep-drawing may be found in "spinning" of one type or another. . . .

T. V. Montgomery,
manager
industrial products div.
Pressed Steel Tank Co.

Eds are always glad for suggestions, no company or process was deliberately slighted in the article. The industry should be glad to hear that a "completely seamless" cylindrical vessel is available. The integral sleeve and dome type vessel was not discounted, see last paragraph of article. Statements on "spinning" were also clearly labeled as reflecting the views of a certain segment of the pressure vessel manufacturers.

Can't Find Spec

. . . Our company is interested in obtaining a copy of Specification MIL-G-11461, regarding quality control programs, referenced in the December, 1958, issue of AMM . . . ("monitoring reliability") . . . when we looked up this number in the INDEX OF SPECIFICATION AND STANDARDS . . . we found only MIL-R-11461A-Rod, ground . . . dated 25 July 52. Would you please send us the correct number. . . .

John B. Harry, manager
quality control dept.
Electro-Mechanical Res. Inc.

Better than that, we are sending a copy of the spec itself. Designation is incorrect and was published incorrectly in DOD report. MIL-G-14461A (Ord) 13, August, 1958, is on the way.

✦

june 29-july 1
national convention on
military electronics
institute of radio engineers
sheraton park hotel, washington, d.c.

◆

june 29-july 3
summer seminar on plastics
pennsylvania state university
university park, pa.

◆

july 16-17
third biennial joint meeting
radio technical commission for
aeronautics and los angeles section,
institute of radio engineers
ambassador hotel, los angeles

◆

july 30-31
symposium on computers
and data processing
denver research institute
stanley hotel, estes park, colo

◆

august 4-5
western regional meeting
american astronautical society
ambassador hotel, los angeles

◆

august 5-7
conference on problems of
hypersonic and space flight
stanford university, stanford, calif.

◆

august 24-26
gas dynamics symposium
american rocket society
northwestern university, evanston, ill.

◆

august 31-september 5
annual congress
international astronautical federation
church house, westminster, london

◆

september 1-2
conference on physical chemistry
in aerodynamic and space flight
OSR (air force), MSVD (general
electric co.)
university of pennsylvania, phila., pa.

◆

september 7-13
1959 farnborough air show
society of british aircraft constructors
farnborough, england

◆

september 28-october 1
fall meeting
american welding society
sheraton-cadillac hotel, detroit

◆

october 5-10
national aeronautic meeting
society of automotive engineers
los angeles, calif.

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index to advertisers

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AMP Inc. 1
Acoustica Associates Inc. 59
Aluminum Co. of America
Inside Front Cover
Apex Machine & Tool Co. 52

B & H Instrument Co., Inc. 11
Beckman Instrument Inc. 51
Bendix Aviation Corp.
Products Div. 15
Brunswick-Balke-Collender Co.
Defense Products Div. . . Back Cover
Bulova
Industrial & Defense Sales 5

Cincinnati Milling Machine Co.
Meta-Dynamics Div 33
Continental Aviation & Engrg. Corp. 68
Craig Tools Inc. 70

General Electric Co.
Flight Propulsion Div. 54
Silicone Div. 41

Hamilton Tool Co. 62

Ideal Industries, Inc. 60

Jones & Laughlin Steel Corp.
Stainless & Strip Div. 25

Kohler Company 75

Laminated Shim Co., Inc. 66
Lukens Steel Co. 21

Matthews & Co., Jas. H. 3
Mill Polishing Corp. 61
Mystik Adhesive Product Inc. 60

Navan Products, Inc.
North American Aviation, Inc. . . 75
North American Aviation, Inc. 71

Olsen Testing Machine Co., Tinius . 74
Osborn Mfg. Co. 56

Raybestos-Manhattan, Inc.
Plastic Products Div. 64
Rolle Mfg. Co. 37

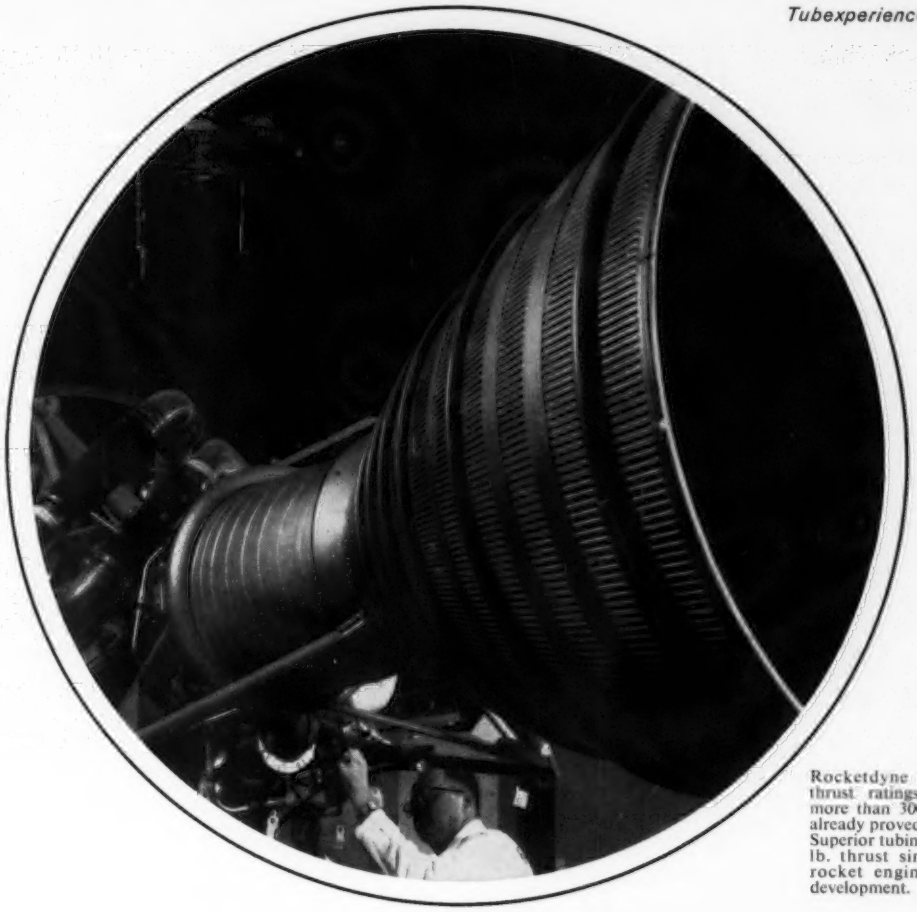
Standard Electric Tool Co. 74
Sturtevant Co., P. A. 77
Superior Tube Co. . . Inside Back Cover
Synchro-Start Products, Inc. 60

Tinsley Laboratories, Inc. 77
Tung-Sol Electric, Inc.
Chatham Electronics Div. 31

U. S. Flexible Tubing Co. 70

White Dental Mfg. Co., S. S. 57

Tubexperience in action



Rocketdyne engines with thrust ratings of 5000 to more than 300,000 lb. have already proved the quality of Superior tubing. A 1,500,000 lb. thrust single chamber rocket engine is now in development.

Superior Thin-Wall Nickel Tubing Survives Rigors of Preparation for Outer Space

Thrust chambers of the Rocketdyne engines that propel the Atlas, Thor and Jupiter missiles into outer space are composed of over 200 pieces of formed and shaped Superior Grade "A" nickel tubing. Tubing must meet rigid design requirements and be amenable to exacting and intricate forming and fabrication. Finished parts are subjected to tests that must insure reliability. Typical of the unusually severe fabrication, test and operational conditions it must survive are the following.

- Die-press operations which develop pressure of 600 psi in the press and up to 20,000 psi in the tube while forming cross-section shapes varying from round to rectangular to octagonal.

- Brazing operations which subject the tube to as many as 15 heating and cooling cycles at approximately 1200°F.

- Test firings far in excess of required tactical maximum in which the only material between the coolant in the tubes and the combustion gases (at approximately 5000°F and high pressures) is the very thin wall of tubing.

Only the highest quality tubing, produced and fabricated with master skills, is good enough for the thrust chambers in which Superior tubing serves. That is why Rocketdyne Division, North American Aviation, Inc., depends on Superior for much of its tubing needs.

Superior's experience in the nuclear and missile tubing field is extensive. More than 120 analyses in a wide range of ID, OD and wall thicknesses are now available. They are described in Bulletin 41. Write for a copy today. Superior Tube Company, 2053 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to ⅝ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

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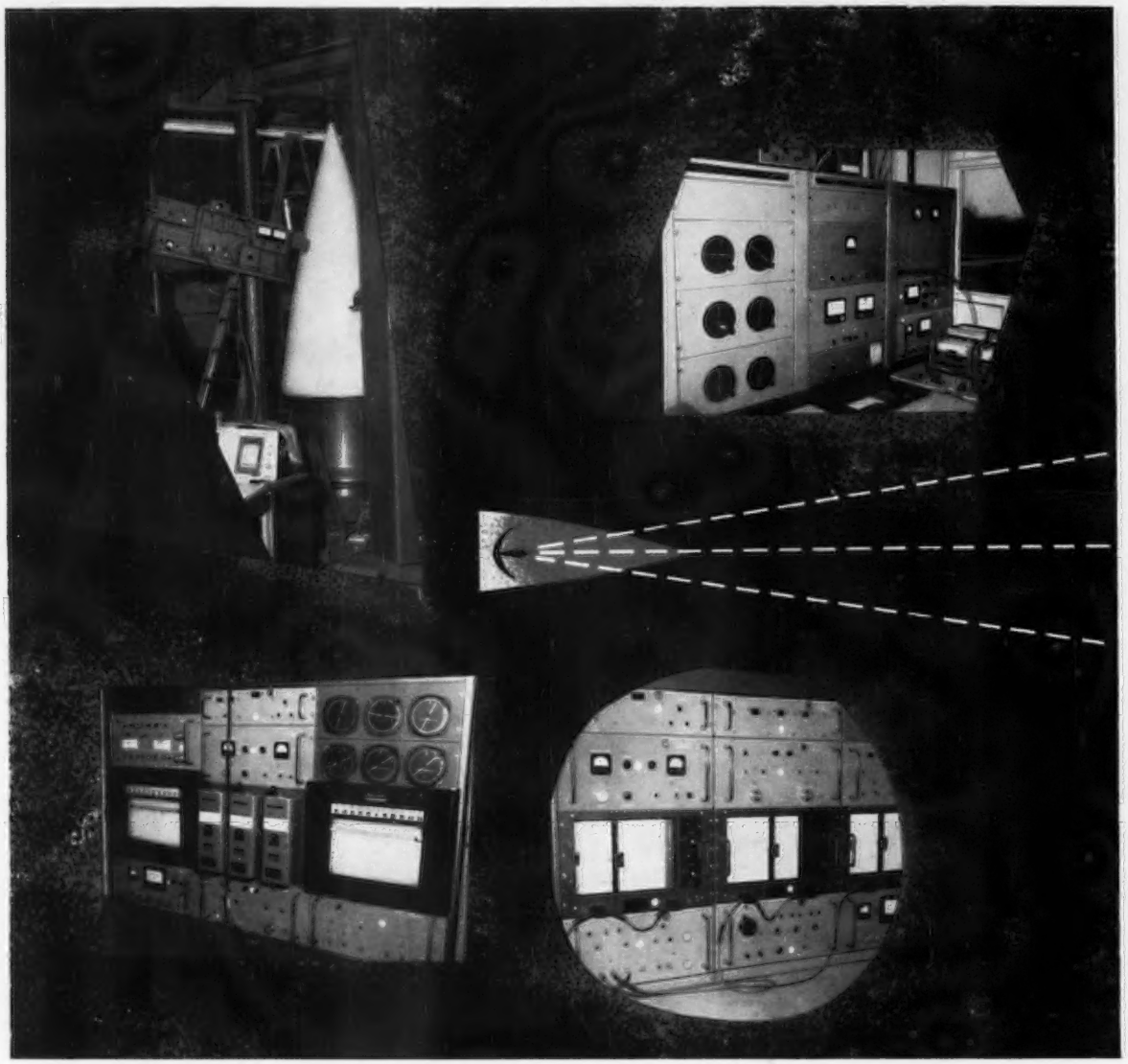

BORESIGHT ACCURACY TO 1/15 MILLIRADIAN? SEE BRUNSWICK

Brunswick-built radomes are setting new highs not only for strength-to-weight ratios, but accuracy as well. The reasons for the accuracy are simple: Brunswick has the test facilities and know-how that are without peer in the industry. Three radome ranges which automatically detect boresight error to an accuracy of 1/12 to 1/15 milliradian are now in full operation at Brunswick.

Soon to be in operation: two 1,000-foot ranges, manually operated, that will assure even more refined accuracy, detecting errors as small as 5 seconds of arc. Also, as an aid to design, quality control and maintenance of electrical tolerances, Brunswick is currently utilizing a one-horn interferometer for accurate IPD measurements and corrections before final range testing.

Behind these extensive test facilities operates an engineering team skilled in both detecting and *correcting* boresight error. To learn how this combination of facilities and engineers can give you uniquely accurate, tough and lightweight radomes, write to: Brunswick-Balke-Collender Company, Defense Products Division Sales Manager, 1700 Messler St., Muskegon, Michigan.

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